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Coastal and Hydraulics Laboratory

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Development Center

First Powerhouse, Bonneville Dam, Columbia River, Oregon
Report 2, Tracking Velocities

Hydraulic Model Investigation

Robert Davidson

April 2000

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Hydraulic Model Investigation

by Robert Davidson

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Preface

Velocity experiments to define the flow conditions upstream of prototype surface collector at the First Powerhouse at Bonneville Dam, Columbia River, Portland, OR, were performed for U.S. Army Engineer District, Portland. Funding for this study was received by U.S. Army Engineer Research and Development Center on 14 July 1998.

This study was conducted in the Coastal and Hydraulics Laboratory (CHL), Vicksburg, MS, ERDC, from August 1998 to October 1998 under the direction of Dr. J.R. Houston, Director, CHL, and Dr. P.G. Combs, Chief, Rivers and Structures Division, CHL.

Model velocity information was obtained and plotted by Ms. Danea Polk, hydraulic technician, under the direct supervision of Mr. Robert A. Davidson, research hydraulic engineer. Analysis of the velocity information and final presentation of the information was accomplished by Mr. Davidson under the supervision of Mr. J. F. George, Chief, Fisheries and Structures Hydrodynamic Branch. This report was written by Mr. Davidson.

During the course of the model study, Mr. Randy Lee and Ms. Karen Kuhn, hydraulic engineers, Portland District, visited ERDC to observe model operation, review experiment results, and participate in experiment planning.

At the time of publication of this report the Acting Director of ERDC was Dr. Lewis Link. The Commander was COL Robin R. Cababa, EN.

1 Introduction

Background

Bonneville Dam is located on the Columbia River at river mile 146.1, approximately 64.36 km (40 miles) east of Portland, Oregon (Figure 1). It is a multipurpose project that consists of the first and second powerhouses, the old and new navigation locks and a 45,308.8 cu m/sec (1,600,000 cfs)-capacity spillway. Construction of the first powerhouse, the old navigation lock and spillway, began in 1933. President Franklin D. Roosevelt dedicated the lock and dam September 28, 1937. The construction of the first powerhouse was completed in 1943. The first powerhouse has a flow capacity of approximately 3,624.704 cu m/sec (128,000 cfs) and a rated power output of 526,700 kW. Construction of the second powerhouse began in 1974 and was completed in 1981. The second powerhouse has a flow capacity of approximately 4,530.88 cu m/sec (160,000 cfs) and a rated power output of 558,200 kW.

Purpose and Scope

Surface collectors are being studied as a possible solution for bypassing juvenile salmon around the turbines at the Bonneville First Powerhouse. To determine if fish will use the surface collector as a passage route, it is necessary to determine how juvenile salmon will react to the surface collector. Juvenile fish tracking studies were conducted during 1998 in the forebay of the Bonneville First Powerhouse in the area of the prototype surface collector (PSC). Pacific Northwest Laboratories (PNL) acquired the fish movement data. Three-dimensional velocity information was obtained from the 1:40-scale model to overlay with the fish movement data to determine if the juvenile salmon were following the flow lines into the PSC. This velocity information will be delivered to the U.S. Army Engineer District, Portland, who in turn will deliver it to PNL for overlaying with fish movement data.

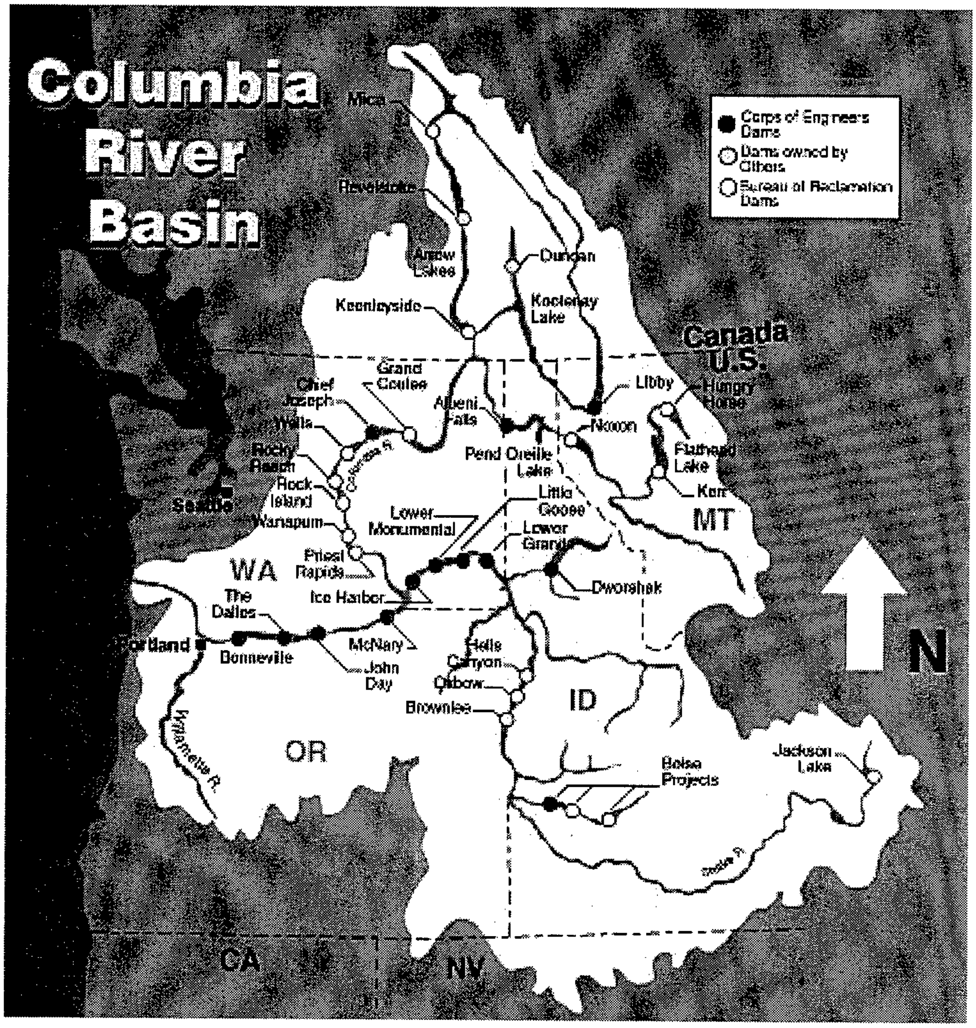

Figure 1. Project location

2 Scale Model

Similitude

Complete similitude in a laboratory model is attained when geometric, kinematic, and dynamic similitude is satisfied. Physical models of hydraulic structures with both internal flow (pressure flow) and external flow (free surface) typically are scaled using kinematic (Froudian) similitude at a large enough scale that the viscous effects in the scaled model can be neglected. Velocities scaled using kinematic similitude (model Froude number equal to prototype Froude number) in a 1:40-scale model have maximum Reynolds numbers at the peak discharge on the order of 10^5, yet the corresponding prototype values are on the order of 10^7.

Because the friction factor decreases with increasing the Reynolds number, the model is hydraulically too rough. The scaled friction losses in the model will be larger than those experienced by the prototype structure. However, the focus of this study is the determination of flow lines in the approach channel and the comparison of the fish movement data to these flow lines. The flow lines are determined through velocity measurements. Only a portion of the powerhouse structure was reproduced so the difference model to prototype friction losses would be difficult to determine. Also, the difference in roughness of the topography between the prototype to the model would be difficult to determine since prototype information on the approach channel is not available. It is very important that the model accurately reproduces enough of the approach topography and specific portions of the intake of the powerhouse to properly develop flow conditions at the powerhouse. The upstream limit of the model was established based on the prototype channel in which the entering flow within the boundaries would be fully developed in the area of consideration. Since the model topography exceeds 20 times the depth upstream from the area being investigated, the velocity measurements in this scale model should compare favorably with those present in the prototype resulting in the determination of accurate flow lines.

Interpretation of Experimental Results

The accepted equations of hydraulic similitude, based on the Froudian relations, were used to express mathematical relations between the dimensions and hydraulic quantities of the model and the prototype. General relations for the transfer of model data to prototype equivalents, or vise versa, are presented in the following tabulation:

Dimension	Ratio	Scale Relations Model:Prototype
Length	Lr=L	1:40
Area	$Ar = Lr^2$	1:1600
Velocity	$Vr=Lr^{1/2}$	1:6.32
Time	$Tr=Lr^{1/2}$	1:6.32
Discharge	$Qr=Lr^{5/2}$	1:10,119

Model Description

A 1:40-scale model of the Bonneville First Powerhouse was constructed in 1995 (Figure 2). All 10-powerhouse units were reproduced from acrylic, including the ice and trash sluiceway and the juvenile bypass channel. Approximately 487.68 m (1,600 ft) of approach topography was also reproduced. The Portland District supplied topographical plots to ERDC, and they were transferred into a digital format. This information was then used to produce templates, which were set to grade in the approach, steel flume that had been fabricated for this model. Concrete was poured and smoothed between the templates. The upstream portions of the new and old navigation locks were reproduced from plastic-coated plywood. In addition, submerged travelling screens and vertical barrier screens were reproduced from brass and installed in the model.

Model PSC Description

Four PSCs (Figure 3) were constructed of plexiglass and installed on the front of Units 3 through 6 (Figure 4). The PSC had a maximum prototype opening of 6.096 m (20 ft), but any opening less than that could be set on the model PSC by the addition of sheet metal coverings. The invert elevation of the PSC floor is at el 30.5 ft. Each individual PSC covers one entire powerhouse turbine unit and the upstream face of the PSC has the same slope as the face of the powerhouse (11.3 deg). Flow will enter the PSC through the front slot and will be passed through the PSC into the three bays of the powerhouse unit of which it is

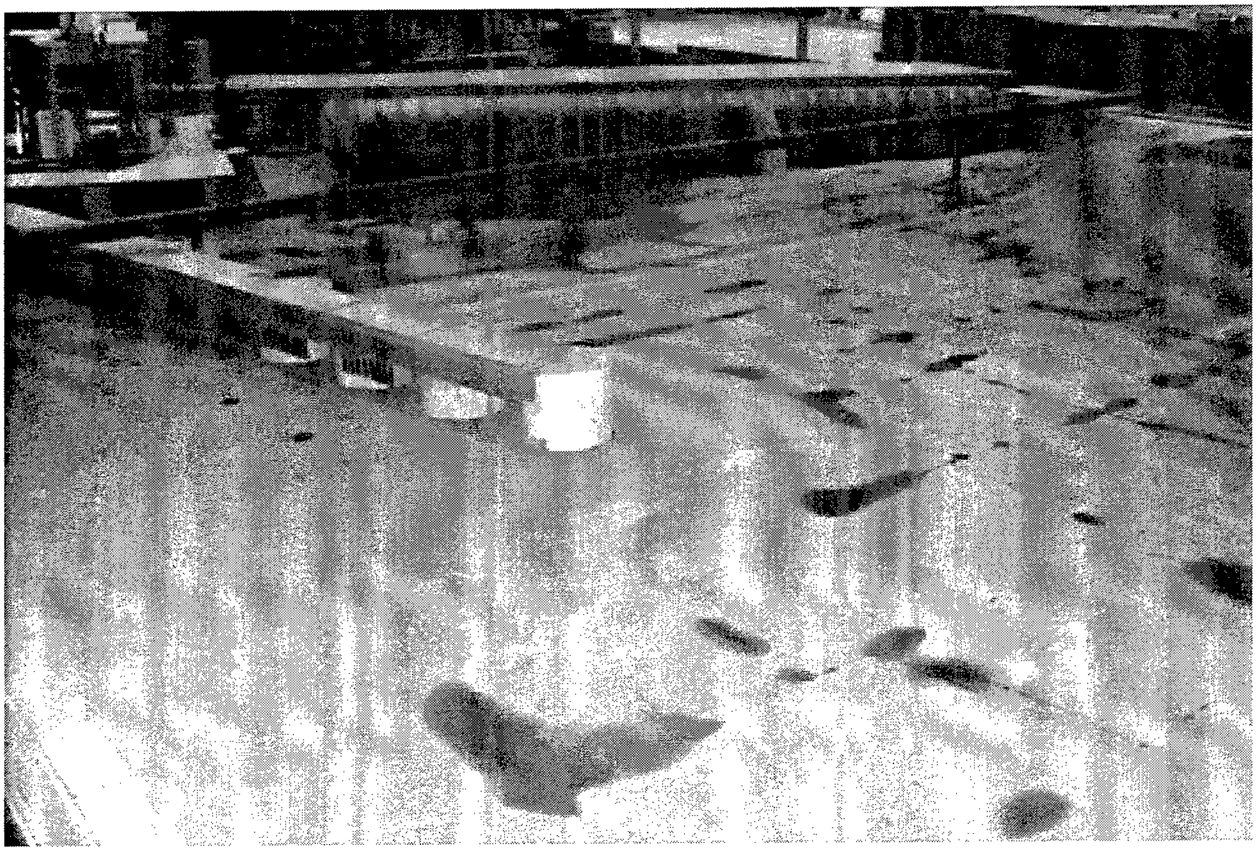

Figure 2. General view of 1:40-scale model

attached. The sides of the PSC have solid walls that will not allow flow to pass out. This means that any juvenile fish that pass through the PSC will enter the powerhouse unit and will either pass through the turbine or will be guided by the submerged travelling screen. Juvenile fish may pass also through PSC into the ice and trash sluiceway, when the ice and trash sluice gate are open in the turbine unit with the PSC in place. Changing the PSC entrance slot width or changing the turbine discharge will affect the flow through the PSC which in turn has an effect of the ratio of flow through the PSC to flow which passes under the PSC.

Calibration of Model

Water is supplied to the model by six pumps. Each pump is capable of supplying 0.0850 cu m/sec (3 cfs) (model value). This provides a total prototype inflow capacity of approximately 5,153.876 cu m/sec (182,000 cfs). A data industrial flow meter was placed in each inflow supply line. Each flow meter was calibrated in the Coastal and Hydraulic Lab's Volumetric Calibration Flume prior to installation in the supply line.

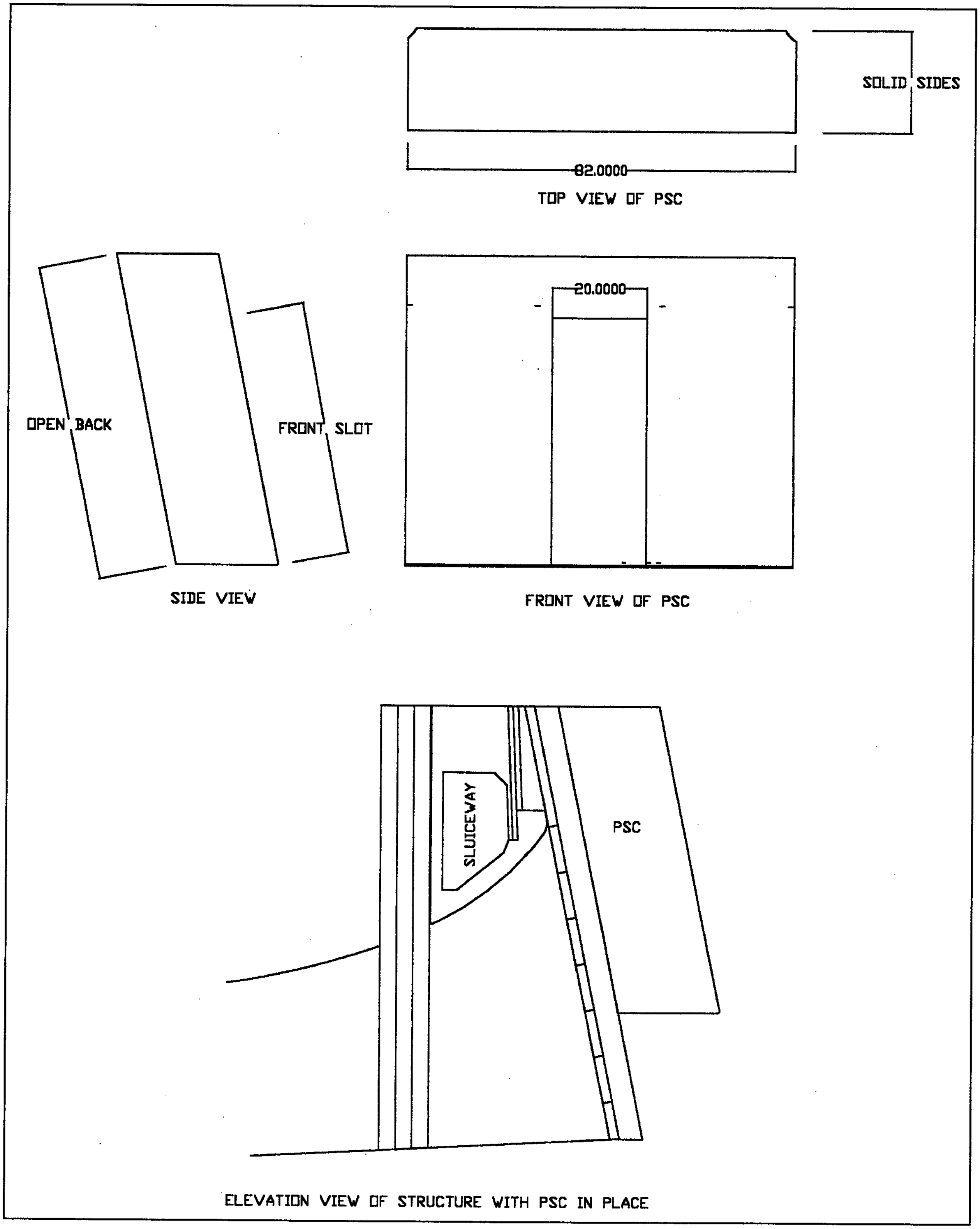

Figure 3. Schematic of PSC

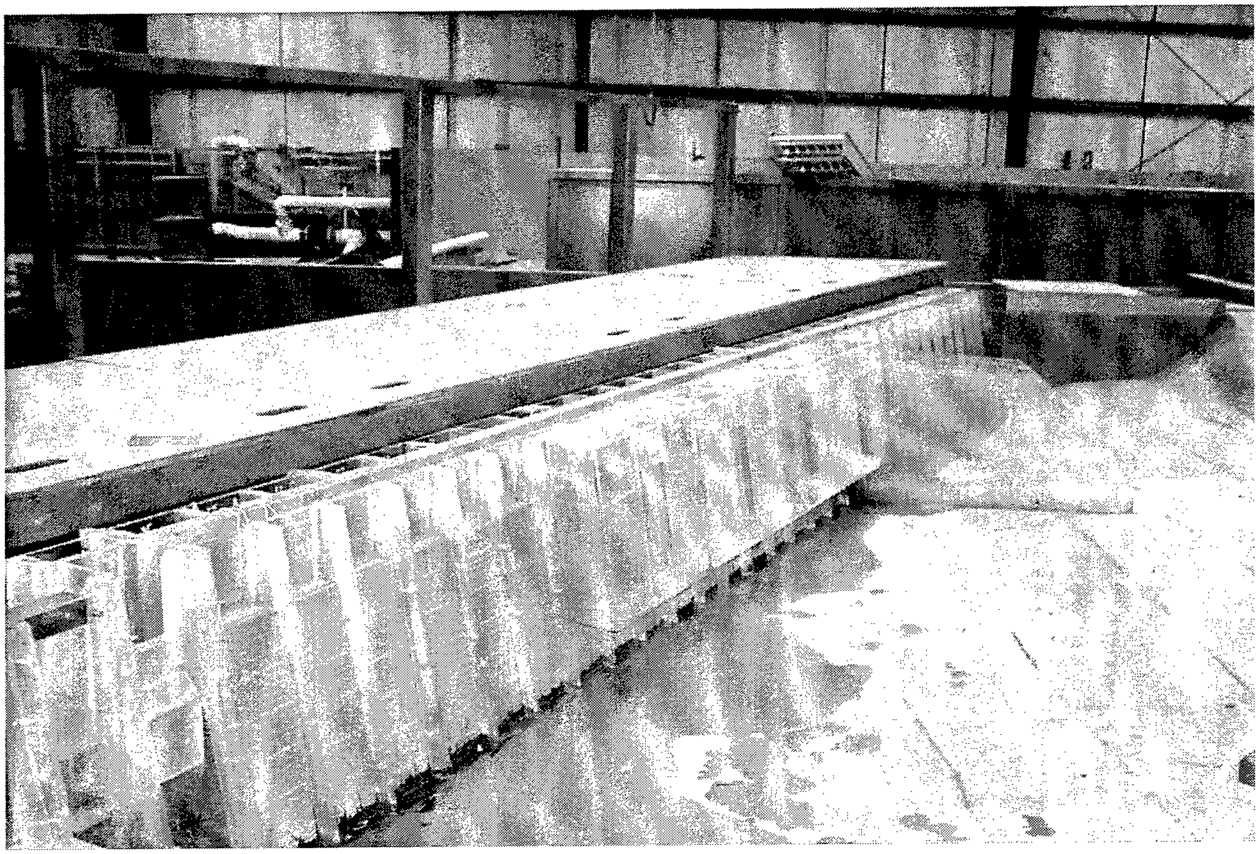

Figure 4. PSCs in place

Each powerhouse unit was constructed with three vertical control gates located at the center line of the turbine. Each one of the three gates is operated separately and controls flow though an individual bay of the powerhouse unit. Based on information obtained from the 1:25-scale Bonneville First Powerhouse section model, the flow through each bay of the powerhouse unit is nearly equal. The control gates in the powerhouse were calibrated (Figure 5) by setting all gates in the powerhouse to a particular opening. A discharge was set and the upper pool was allowed to settle. This head pool was recorded and then the inflow was increased in the model. This procedure was repeated until the upper pool elevation exceeded elevation[1] (el) 80. This entire procedure was repeated until the flow through each unit exceeded 396.452 cu m/sec (14,000 cfs).

Velocity information was obtained in the model with an Acoustic Doppler Velocity Meter (ADV). Calibration of this instrument was performed by the manufactor and no additional calibration was required.

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[1] All elevation (el) cited herein are in feet referenced to the National Geodetic Vertical Datum (to convert feet to meters, multiply number of feet by 0.3048).

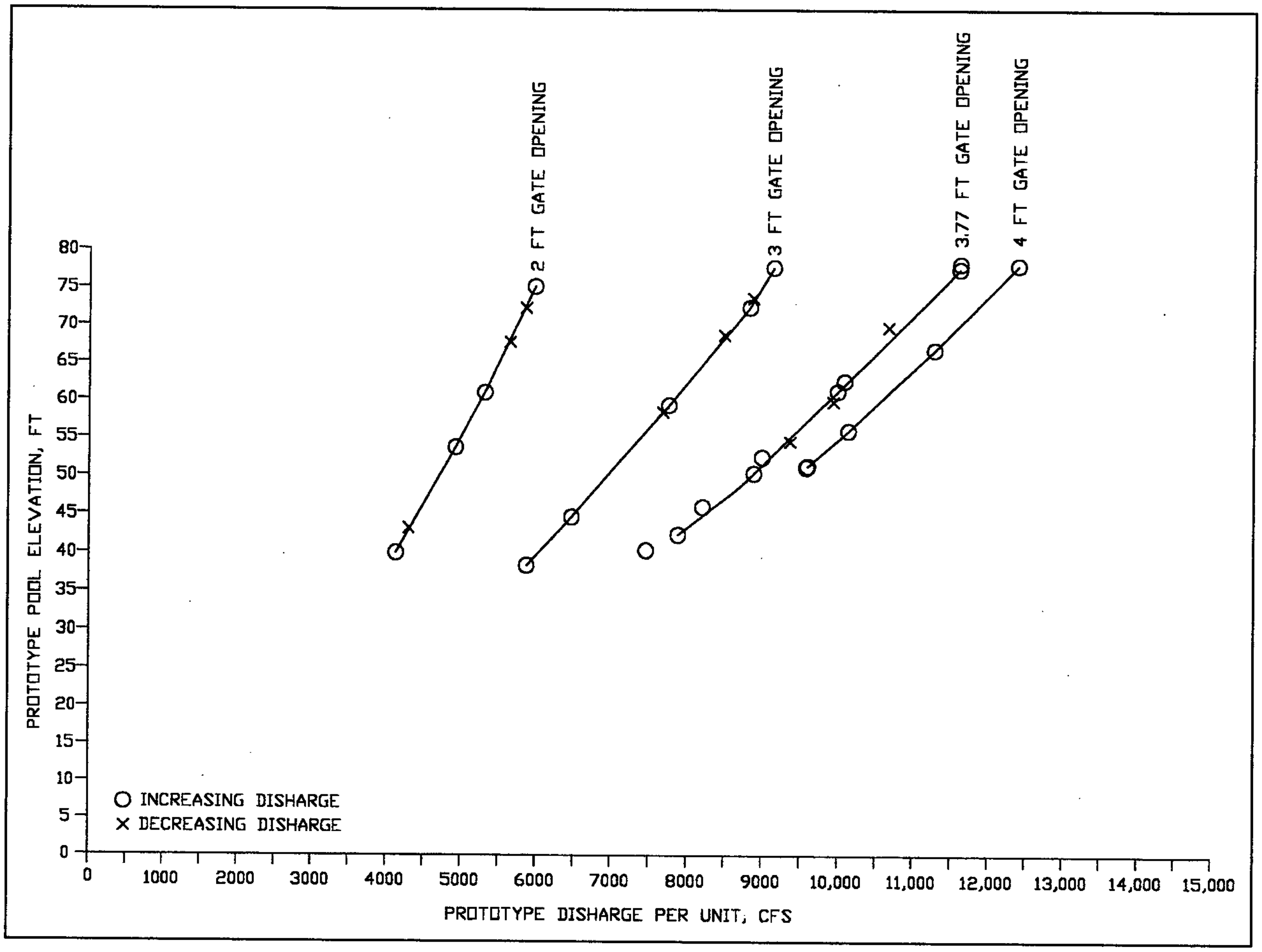


Figure 5. Gate calibration curves

3 Model Experiments and Results

Experimental Conditions

The scope of work that was sent to ERDC by CENWP requested velocity information be obtained in a 2-m by 2-m (prototype) grid around the entrance to the PSC on Unit 3 for both a 1.524 and 6.096-m (5 and 20-ft) slot opening with a floor elevation of 9.2964 m (30.5 ft). The powerhouse discharge settings were as follows: for Units 1, 2, 7, 8, 9, and 10, discharges were set at 319.9934 cu m/sec (11,300 cfs); Units 3 and 5 discharges were set at 277.5164 cu m/sec (9,800 cfs); Units 4 and 6 were off. The forebay elevation was 74.5. Sluiceway10C was open to el 71.5, sluiceway 5B was open to el 71.8, sluiceway 3B was open to el 72.0 and sluiceway 7A was open to el 73.9. These were the average prototype First Powerhouse conditions during the fish tracking experiments in 1998.

1.5240-m (5-ft) slot experiments

The model was set up according to the outlined experimental conditions. Two strips of sheet metal were added to the front of the PSC to reduce the slot entrance width from 6.096 m to 1.5240 m (20 ft to 5 ft). Velocities were obtained at a depth of 0.2926 m (0.96 ft) along the center line of the PSC and upstream of the PSC in 1.9995-m (6.56-ft) increments to a distance of 16.1331 m (52.93 ft). Velocities were also obtained at 1.9995, 3.999, 5.9985, and 8.001 m (6.56, 13.12, 19.68, and 26.25 ft) to the left and right (looking downstream) of each velocity measurement along the center line. This grid was repeated for depths of 1.9995, 3.999, 5.9985, 8.001, 9.9974, 12.0, 13.9995, 15.999, 17.9984, 19.9813, 22.0005, and 23.0002 m (6.56, 13.12, 19.68, 26.25, 32.8, 39.37, 45.93, 52.49, 59.05, 65.62, 72.18, and 75.46 ft). Measured velocities showed a fairly equal velocity distribution of 16.6036 m (54.49 ft) upstream of the PSC (Plates 1-9). However, the closer the velocity was measured to the PSC (except for along the center line) the higher the velocity magnitude was below the collector than above the floor of the collector. This shows the blockage of flow to the turbine caused by the PSC which results in a steeper downward flow component above the collector floor. Velocity measured along the center line

showed a closer velocity magnitude and direction relationship between flow below the PSC floor and flow above the PSC floor (Plate 1). This indicates that if juvenile fish followed flow lines they might enter the PSC if they happen to be in the flow lines that supply water to the PSC. The velocities recorded in Plates 1- 9 reflect only the vertical and perpendicular velocity components. Plan view plots (lateral and perpendicular velocity components) indicate that fish that are to the right (looking downstream) of the PSC entrance flow line may be directed to the PSC (Plates 10-22). The negative side of the flow area to the right (and left) of the center line is that this is in an area where the vertical component of the velocity becomes more negative (downward) the closer it approaches the PSC (Figure 6). Only biological fish tracking experiments performed at the prototype structure with the PSC in place will determine if the conditions described by these velocity experiments are conducive to effective fish collection.

6.096-m (20-ft) slot experiments

The model was set up according to the outlined experimental conditions. The slot opening on the front of the PSC was 6.096 m (20 ft). Velocities were obtained at a depth of 0.2926 m (0.96 ft) along the center line of the PSC and upstream of the PSC in 1.9995-m (6.56-ft) increments to a distance of 16.1331 m (52.93 ft). Velocities were also obtained at 1.9995, 3.999, 5.9985, and 8.001 m (6.56, 13.12, 19.68, and 26.25 ft) to the left and right, looking downstream, of each velocity measurement along the center line. This grid was repeated for depths of 1.9995, 3.999, 5.9985, 8.001, 9.9974, 12.0, 13.9995, 15.999, 17.9984, 19.9813, 22.0005, and 23.0002 m (6.56, 13.12, 19.68, 26.25, 32.8, 39.37, 45.93, 52.49, 59.05, 65.62, 72.18, and 75.46 ft). Measured velocities showed a fairly equal velocity distribution 15.999 m (52.49 ft) upstream of the PSC (Plates 23-31). However, the closer the velocity was measured to the PSC (except for along the center line and 1.9995 m (6.56 ft) to the left and right of center line) the higher the velocity was below the collector floor than above the floor. This shows the blockage of flow to the turbine that the PSC causes. Velocity measured along the center line and 1.9995 m (6.56 ft) to the left and right of center line showed a higher velocity, at the face of the PSC, above the floor of the PSC than velocities below the PSC floor. This is true at the PSC face, but the velocities upstream showed a more comparable top to bottom velocity magnitude. This indicates that if juvenile fish followed the flow lines they might enter the PSC if they happen to be in the flow lines that supply water to the PSC. The velocities recorded in Plates 23-31 reflect only the vertical and perpendicular velocity components. Plan view plots (lateral and perpendicular velocity components) indicate that fish that are to the right (looking downstream) of the PSC entrance flow line may be directed to the PSC (Plates 34-44). The negative side of the flow area to the right (and left) of the center line is that this is in an area where the vertical component of the velocity becomes more negative (downward) the closer it approaches the PSC. This was not as dramatic as the vertical velocities components obtained with the 1.524-m (5-ft) slot

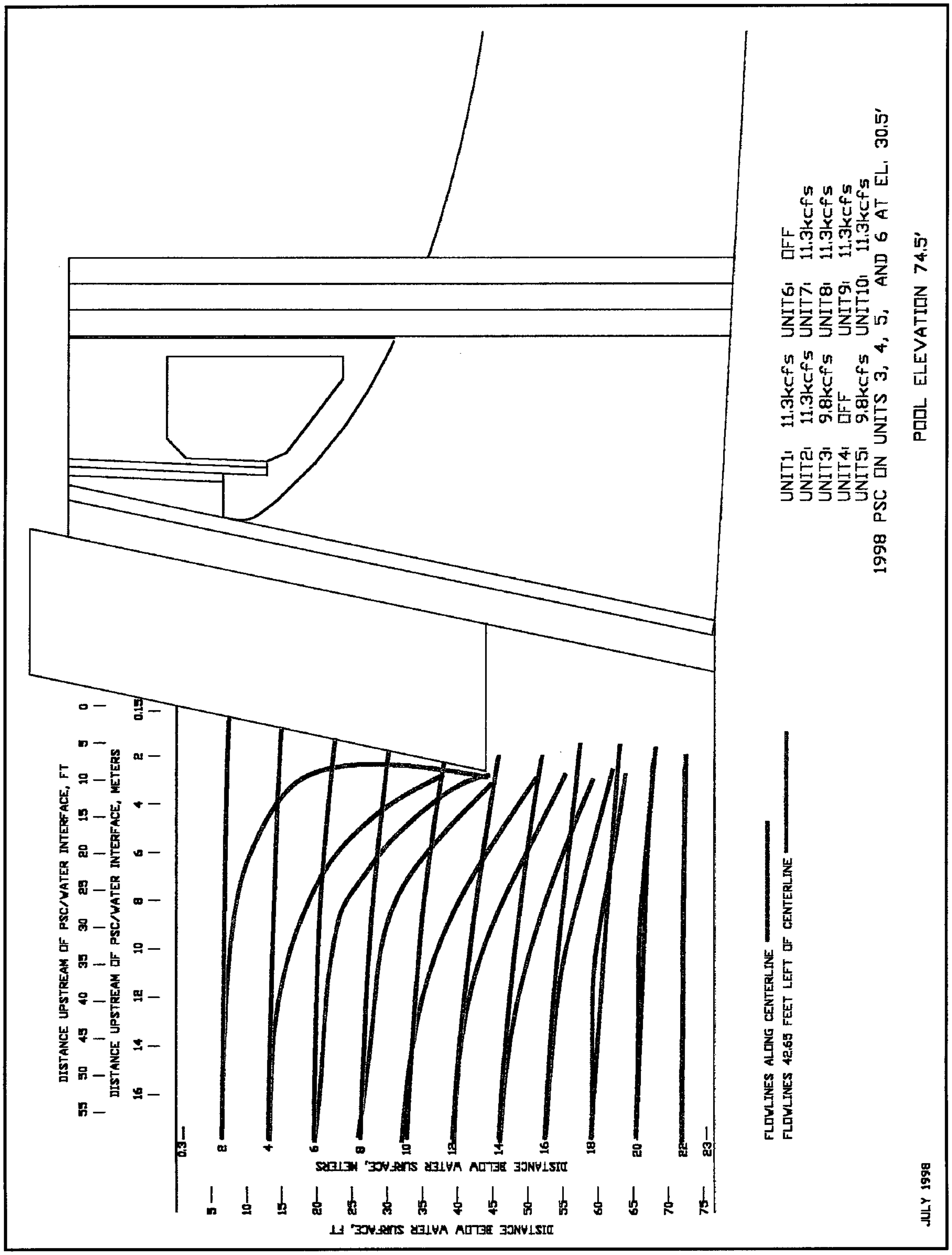


Figure 6. Flow line comparisons

opening, but it still occurs with the 6.096-m (20-ft) slot opening. Only biological experiments performed at the prototype structure with the PSC in place, with a 6.096-m (20-ft) opening, will determine if the conditions described by these velocity experiments are conducive to effective fish collection.

4 Conclusions and Recommendations

The 6.096-m (20-ft) PSC slot opening velocity profiles indicated a higher potential for capturing a greater number of fish than the 1.524-m (5-ft) if fish follow flow lines (Figure 7). This is because the 6.096-m (20-ft) slot opening reduces the blockage effect of the PSC by allowing more turbine flow to pass through the PSC. The velocity profiles showed a negative (downward) vertical velocity component the closer the flow was to the PSC face for both a 1.524-m (5-ft) and 6.096-m (20-ft) opening. Field results of fish tracks, with comparable powerhouse conditions, should be compared to these approach flow conditions in order to truly assess the effectiveness of the PSC on intercepting juvenile salmon. This will be done by PNL.

Also, since the flow of the turbine greatly affects the flow through the PSC, fish tracking information should be obtained for several different turbine loadings for both the 1.524-m (5-ft) and 6.096-m (20-ft) PSC openings. Velocity information should be obtained for each of these conditions and these should be compared to the fish track information. This is necessary to insure enough fish behavior and hydraulic information is available to design a permanent surface collector for this project.

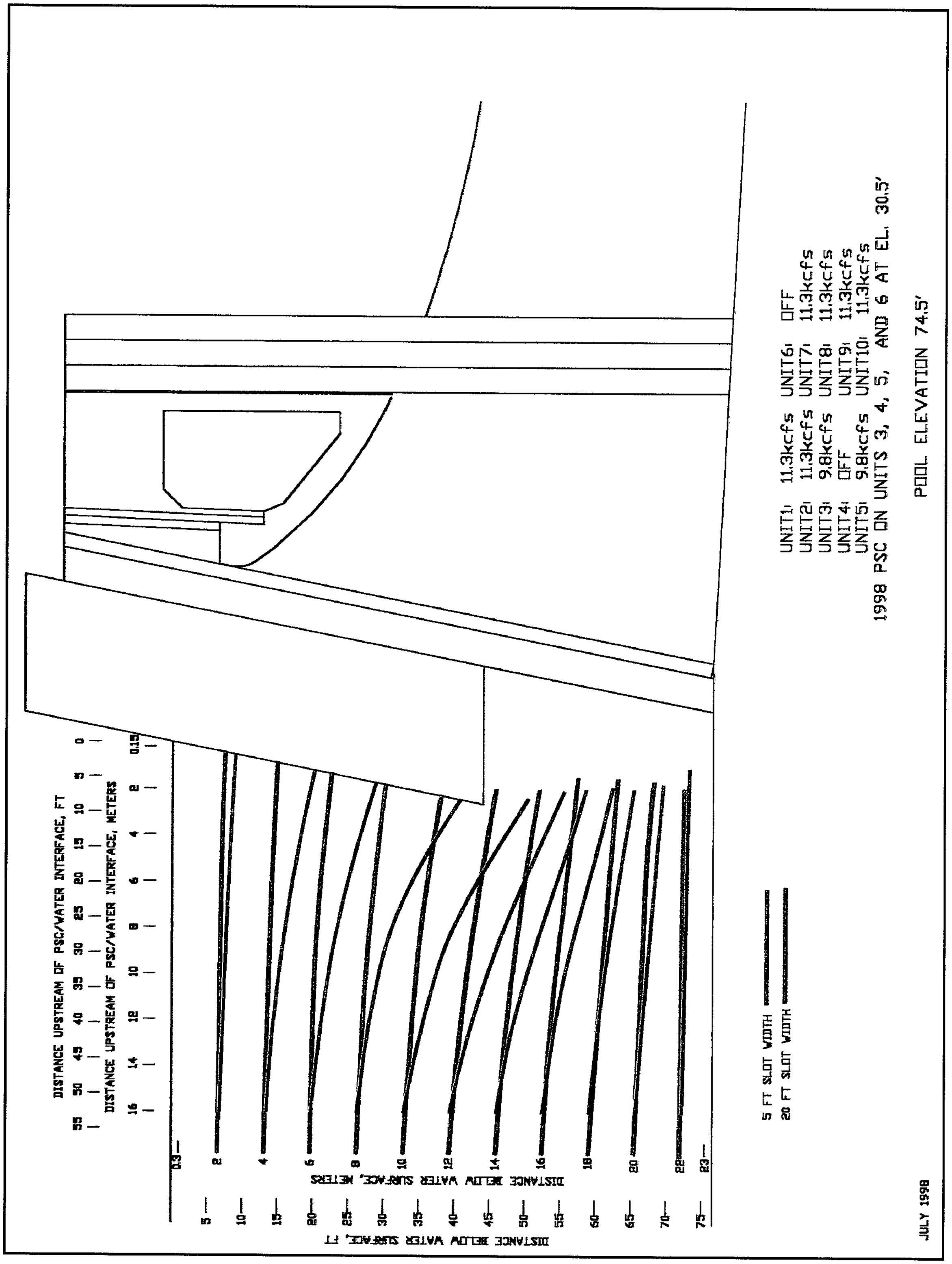
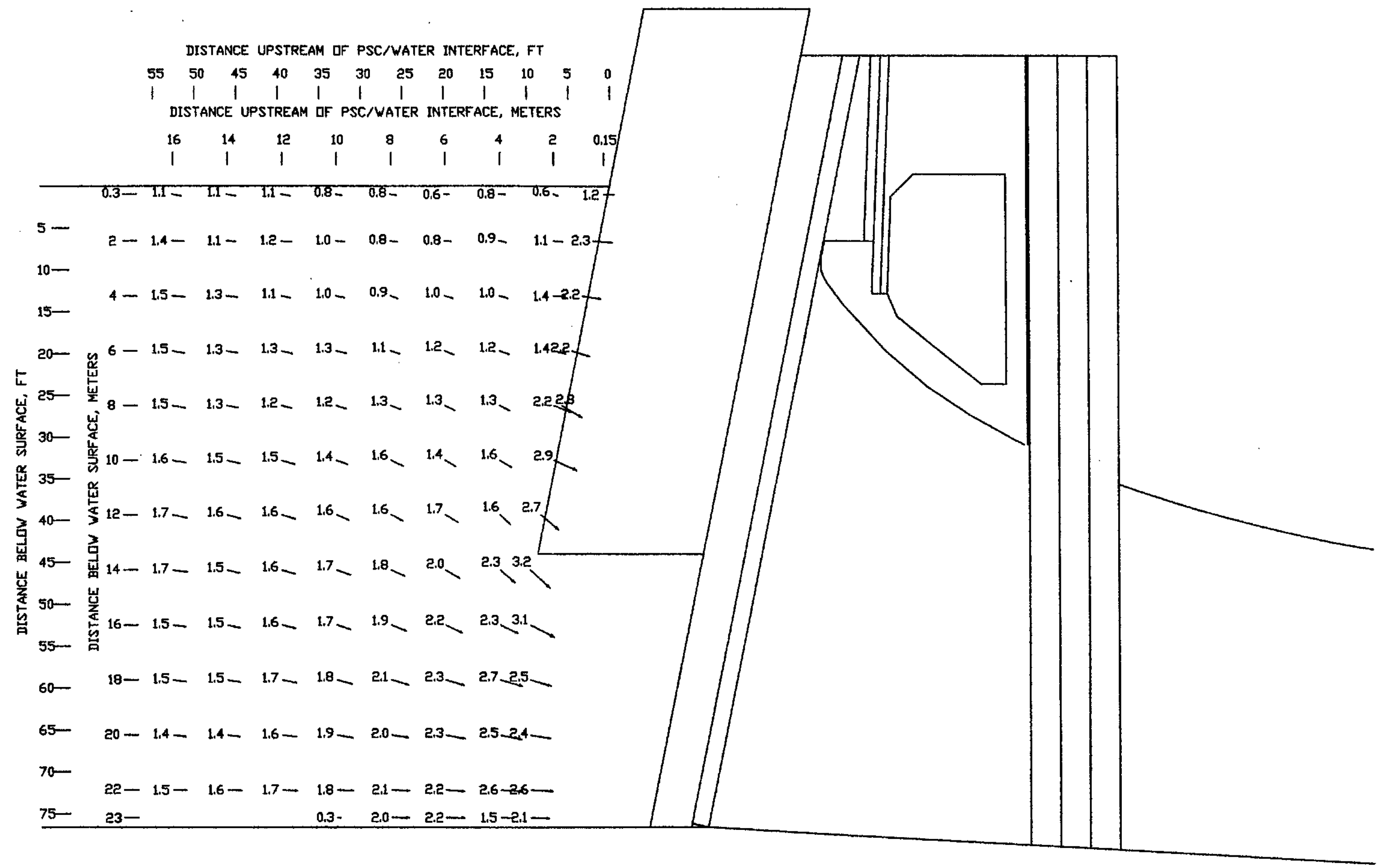


Figure 7. Center line flow line comparisons



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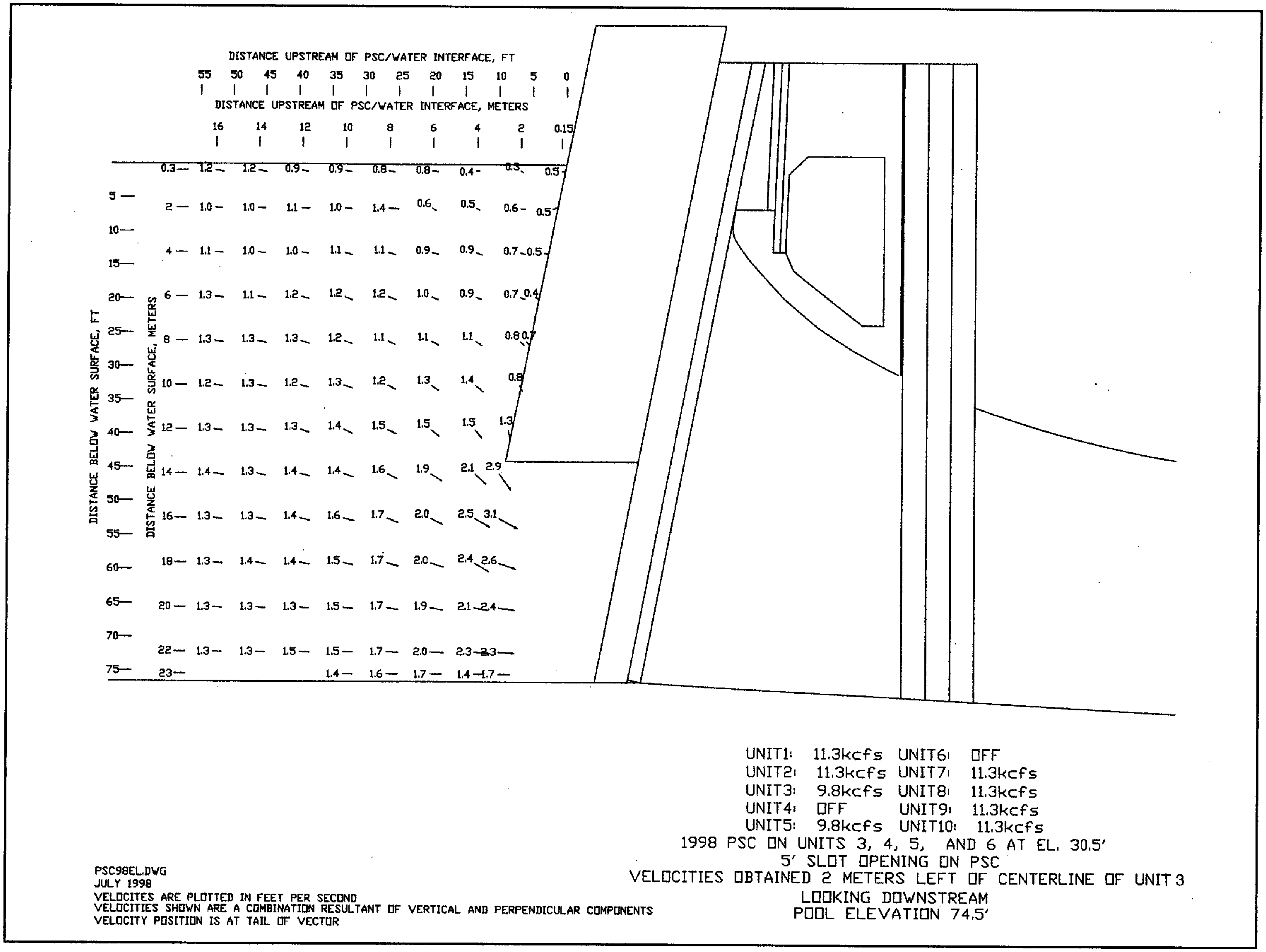
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs
1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
5' SLOT OPENING ON PSC
VELOCITIES OBTAINED ALONG CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR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DISTANCE UPSTREAM OF PSC/WATER INTERFACE, METERS
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DISTANCE BELOW WATER SURFACE, FT
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
DISTANCE BELOW WATER SURFACE, METERS
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2 1.0 1.0 1.1 1.0 1.4 0.6 0.5 0.6 0.5
4 1.1 1.0 1.0 1.1 1.1 0.9 0.9 0.7 0.5
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UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs
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5' SLOT OPENING ON PSC
VELOCITIES OBTAINED 2 METERS LEFT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'
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JULY 1998
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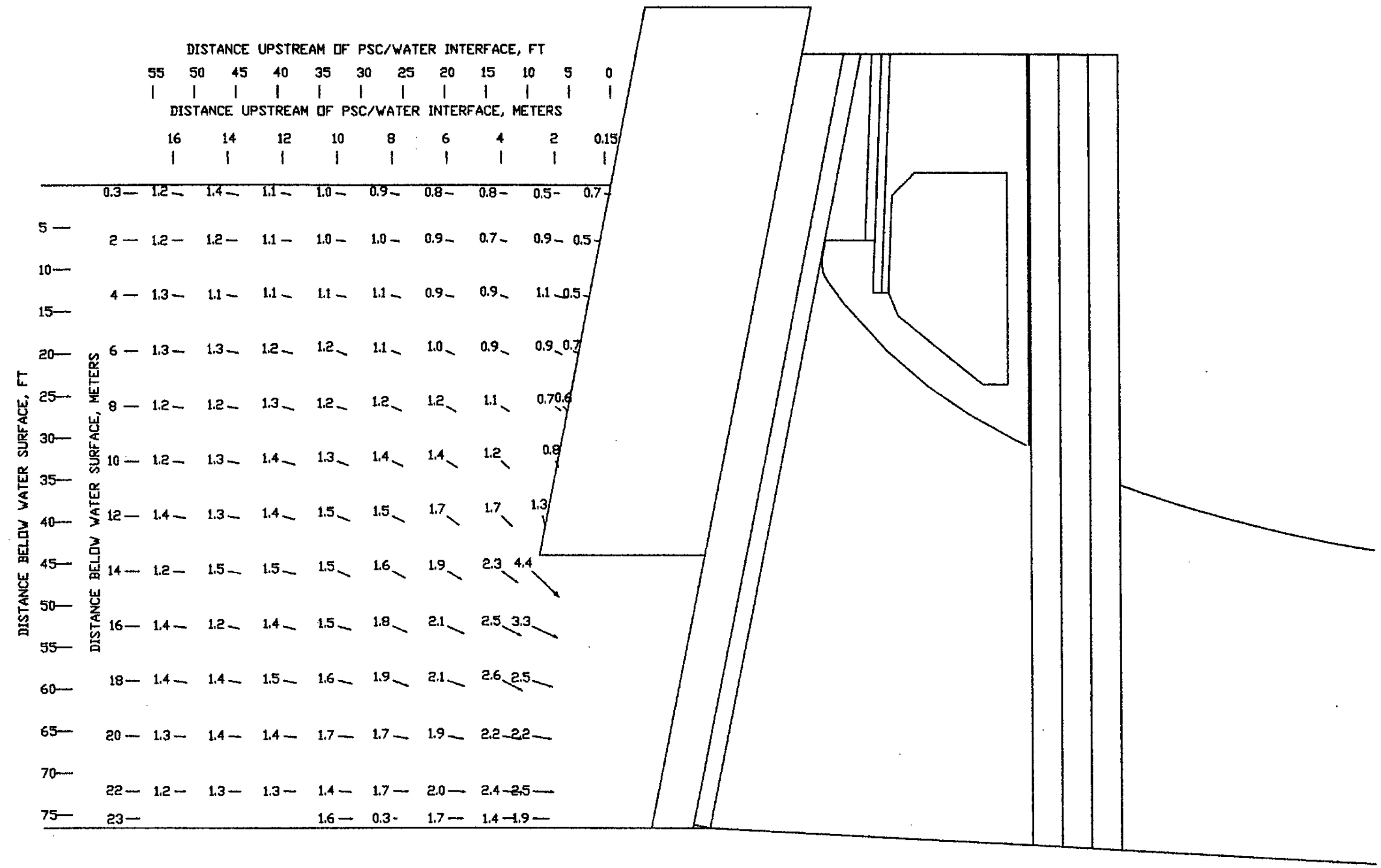
Plate 2



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UNIT5: 9.8kcfs UNIT10: 11.3kcfs

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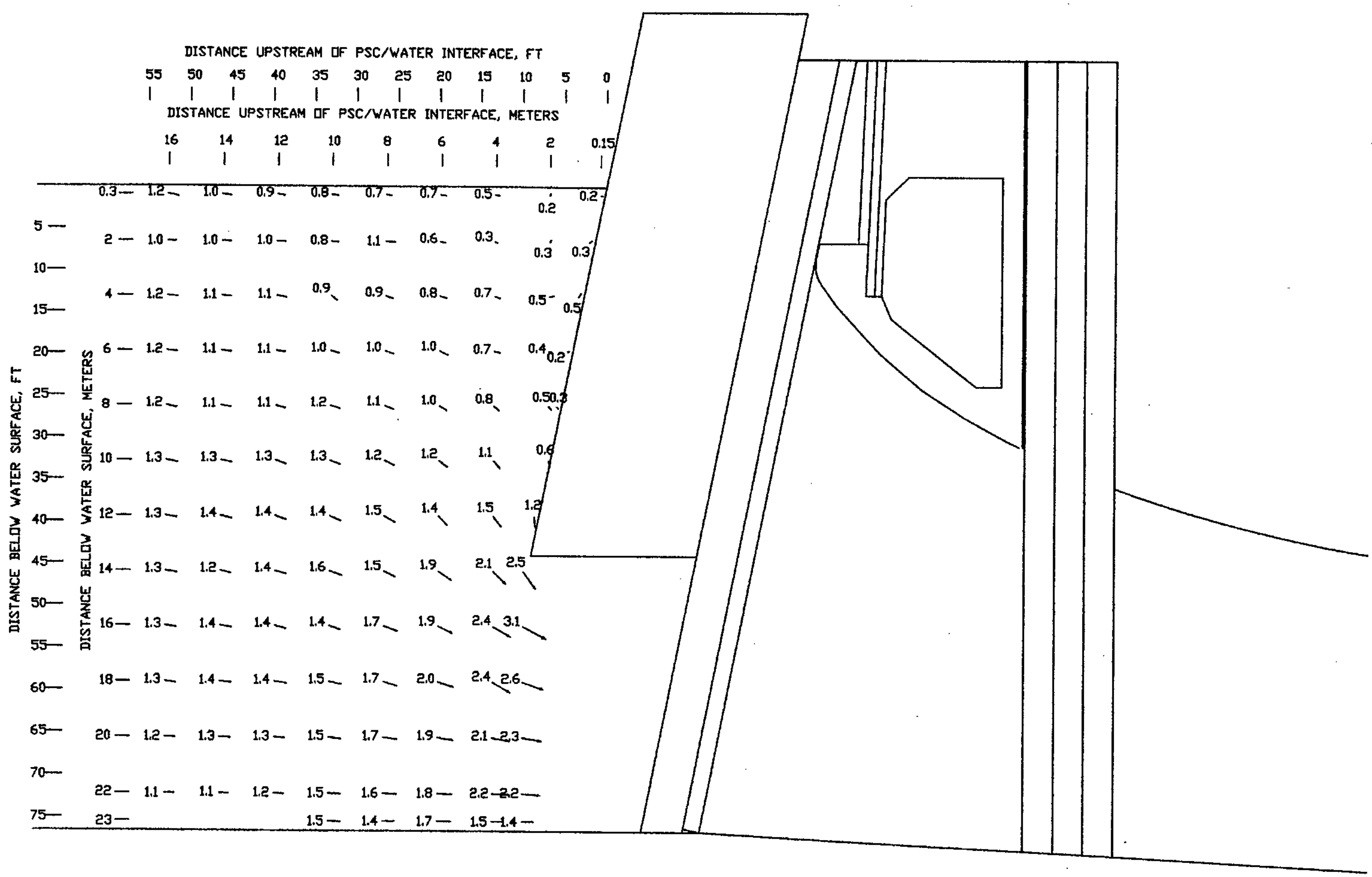

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UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
5' SLOT OPENING ON PSC
VELOCITIES OBTAINED 4 METERS LEFT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

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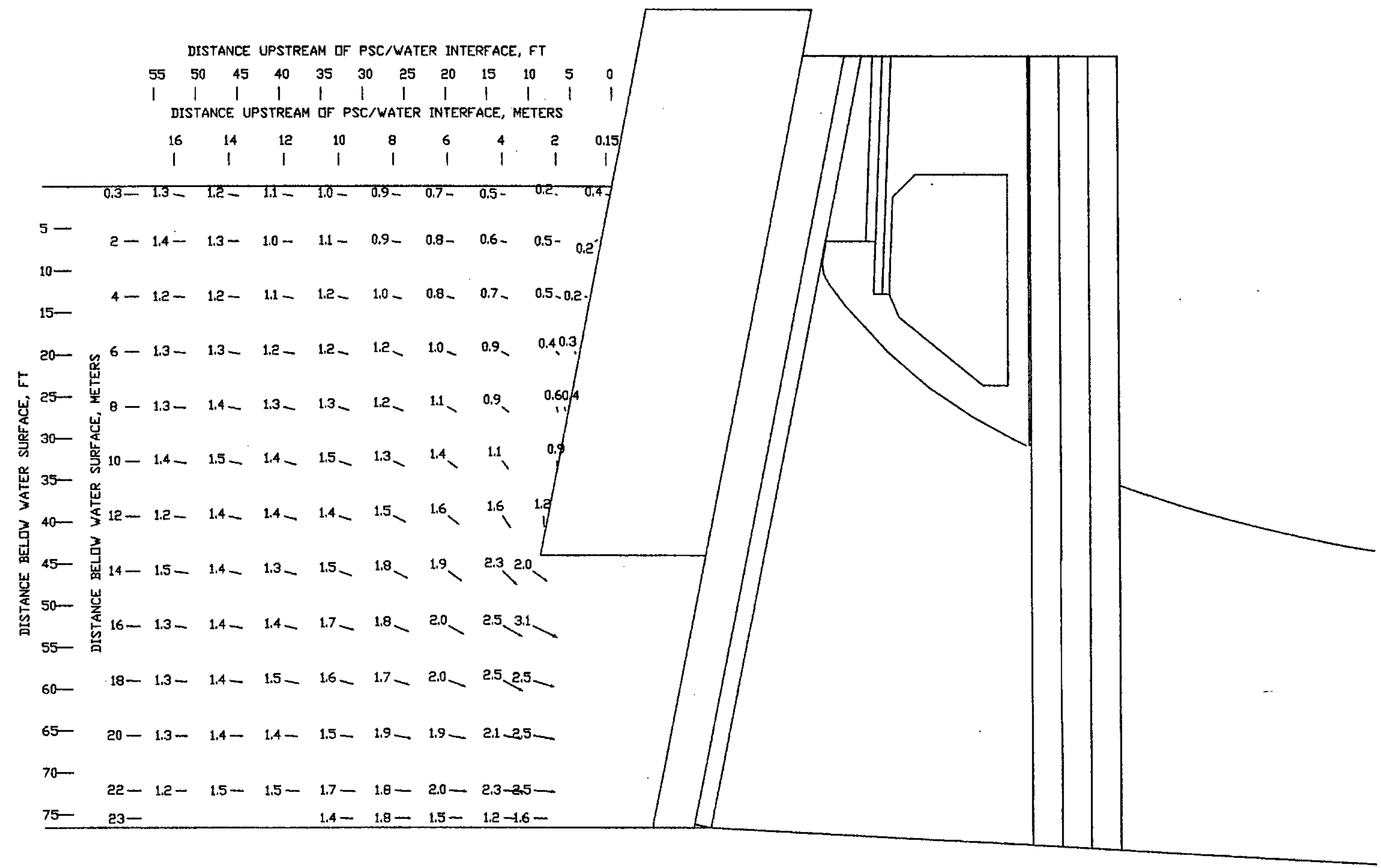
Plate 4



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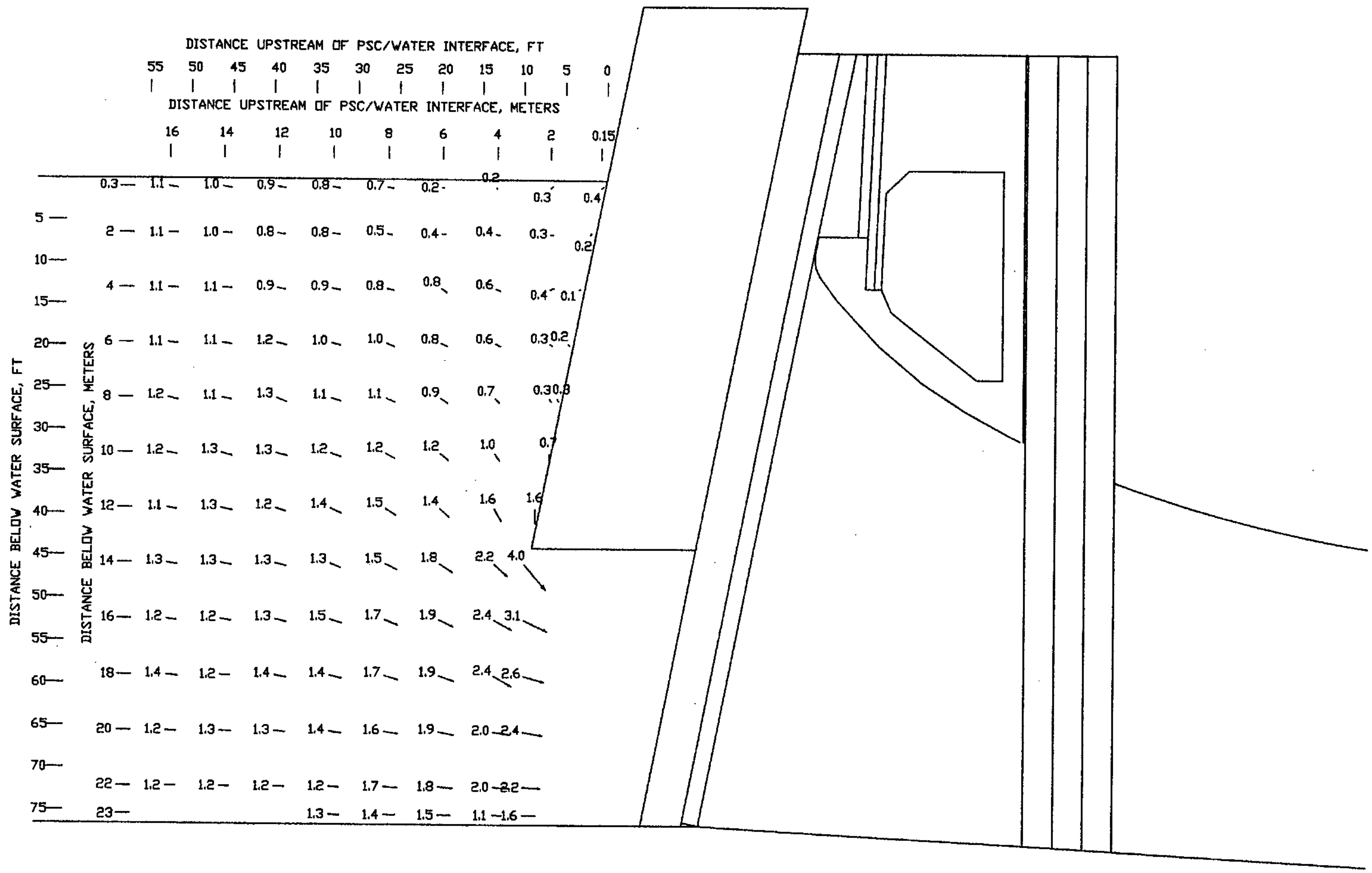

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LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

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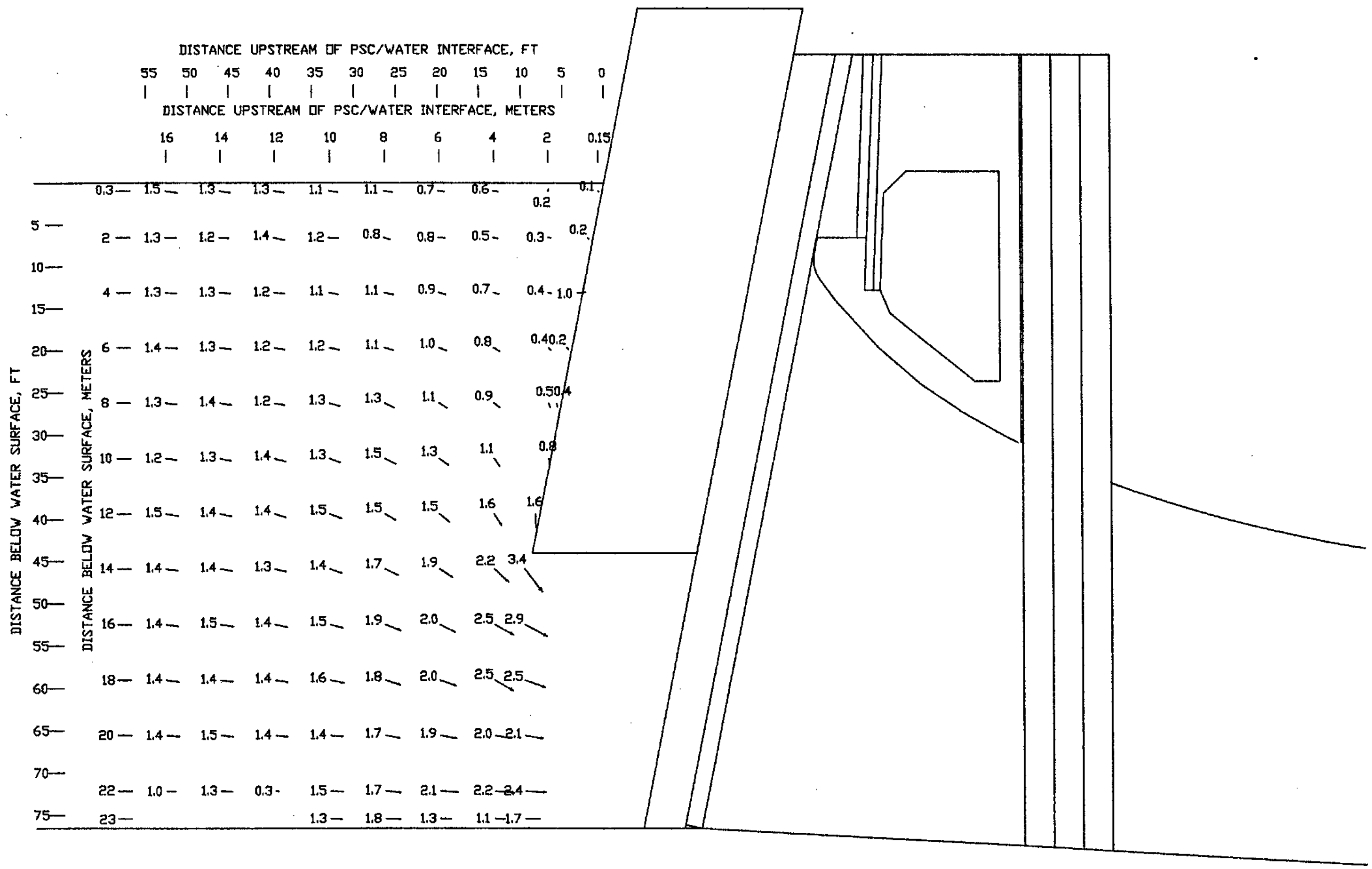
Plate 6



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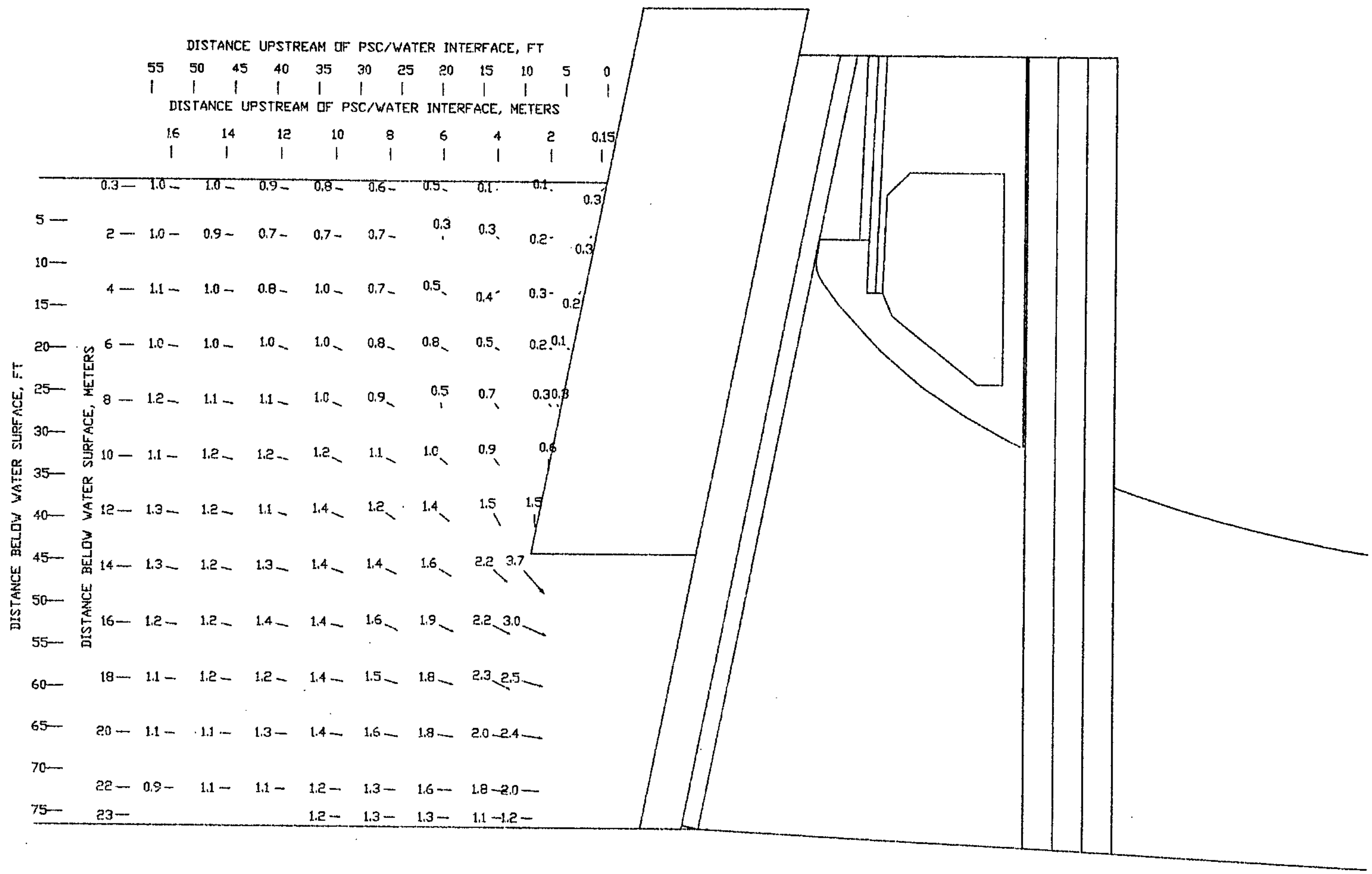
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5′
5′ SLOT OPENING ON PSC
VELOCITIES OBTAINED 6 METERS RIGHT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5′

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

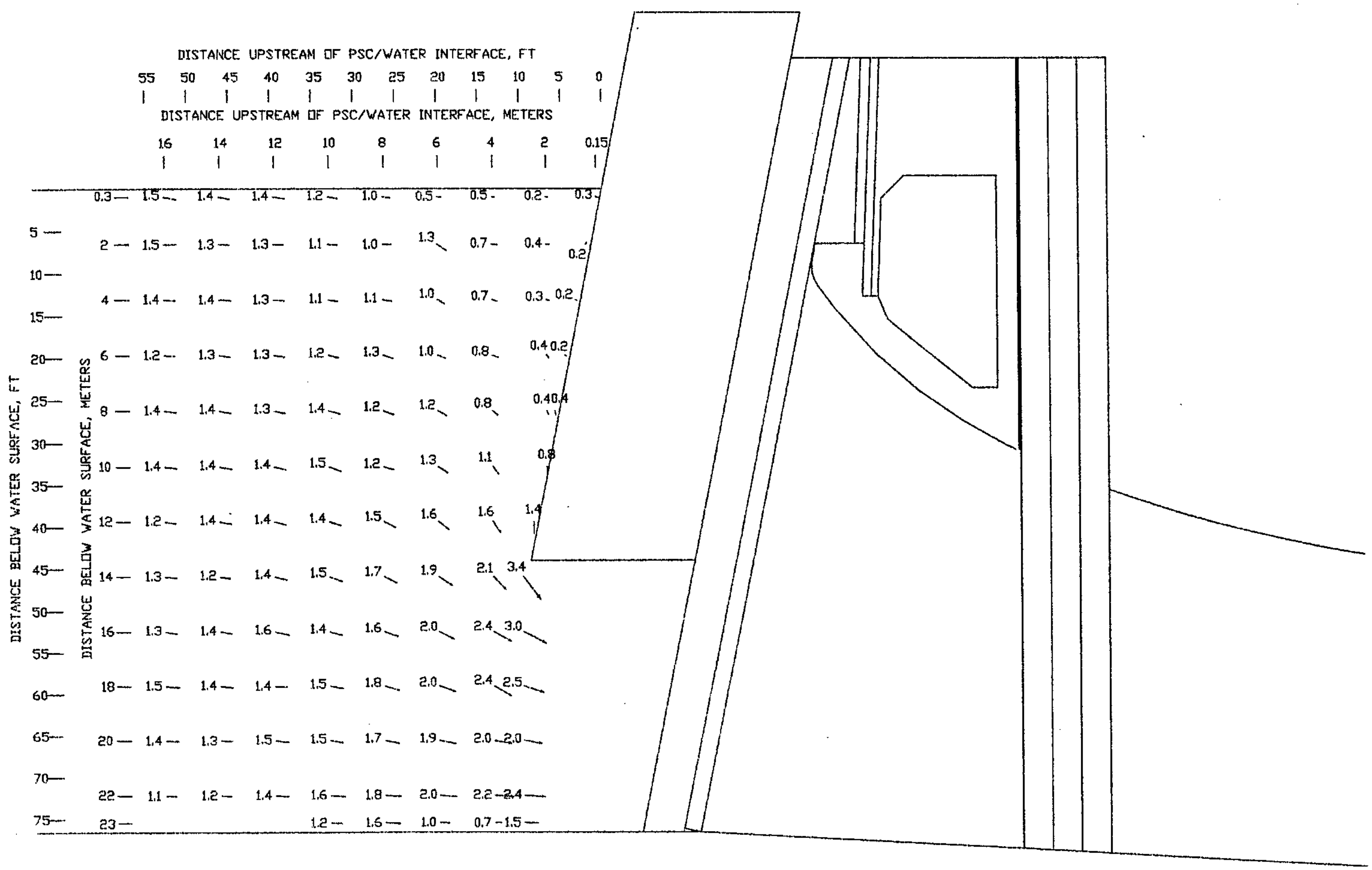


UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
5' SLOT OPENING ON PSC
VELOCITIES OBTAINED 8 METERS LEFT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

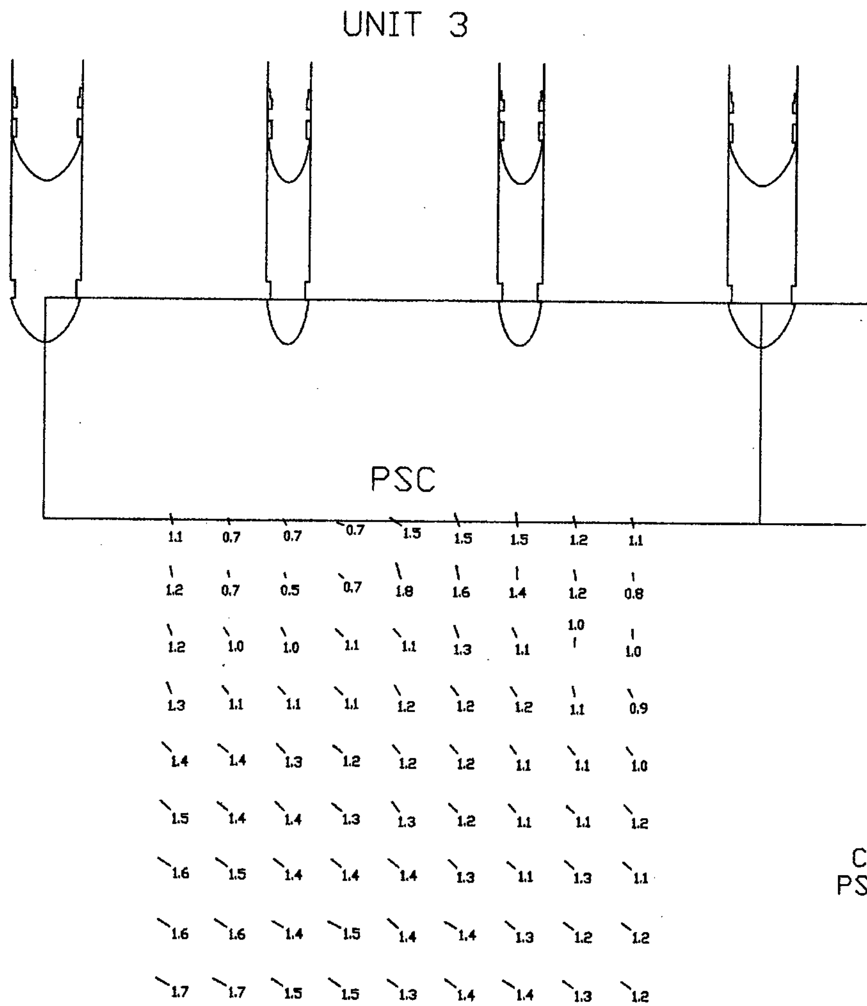
Plate 8



UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
5' SLOT OPENING ON PSC
VELOCITIES OBTAINED 8 METERS RIGHT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

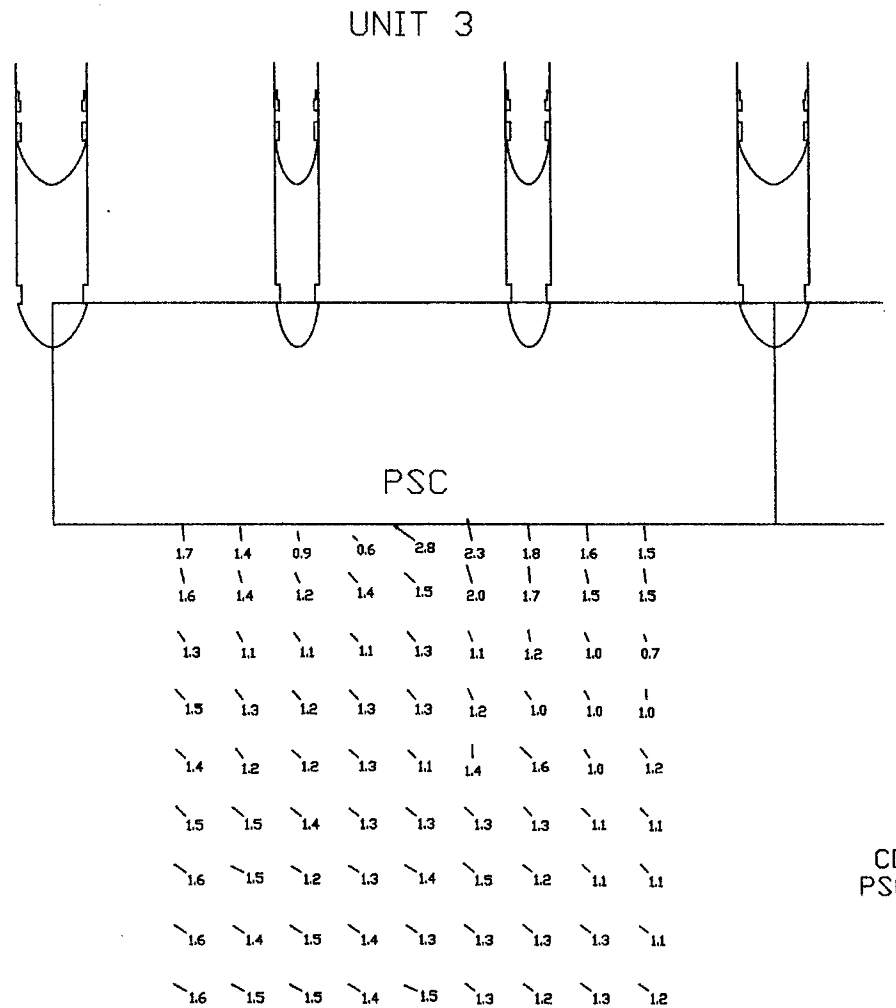


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 0.3 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

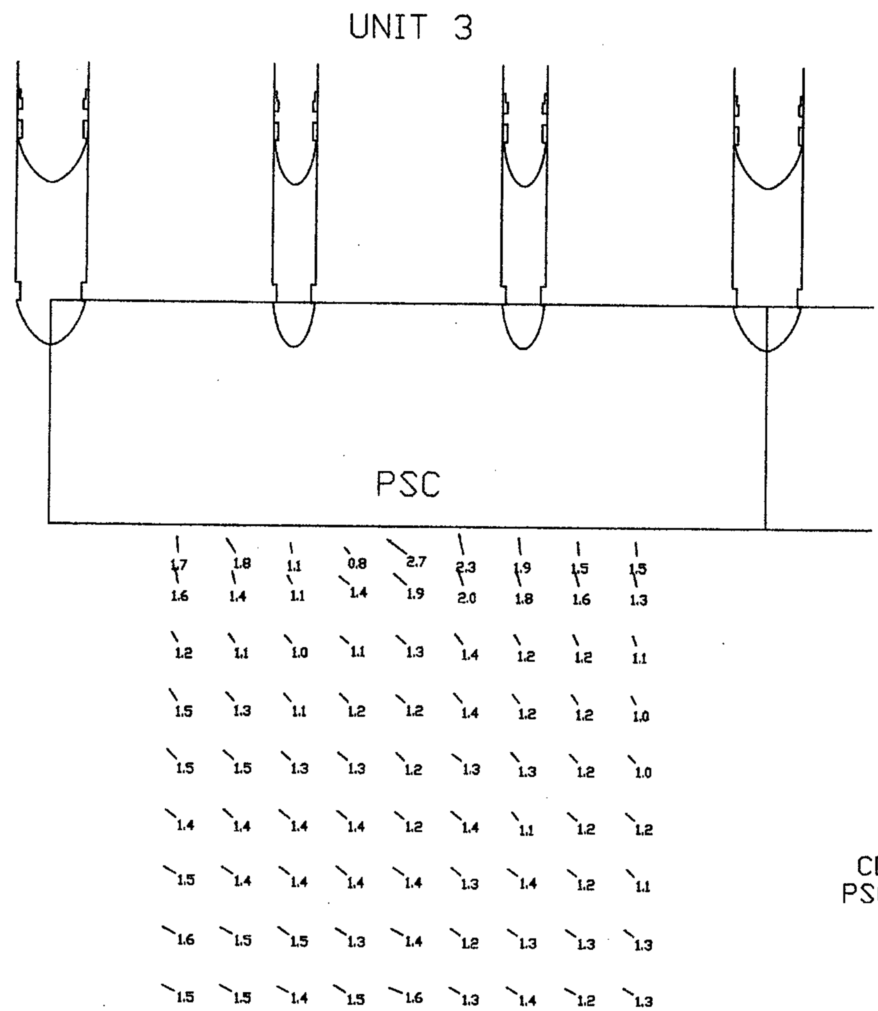


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1: 11.3	UNIT 6: OFF
UNIT2: 11.3	UNIT7: 11.3
UNIT3: 9.8	UNIT8: 11.3
UNIT4: OFF	UNIT9: 11.3
UNIT5: 9.8	UNIT10: 11.3

VELOCITIES 2 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR



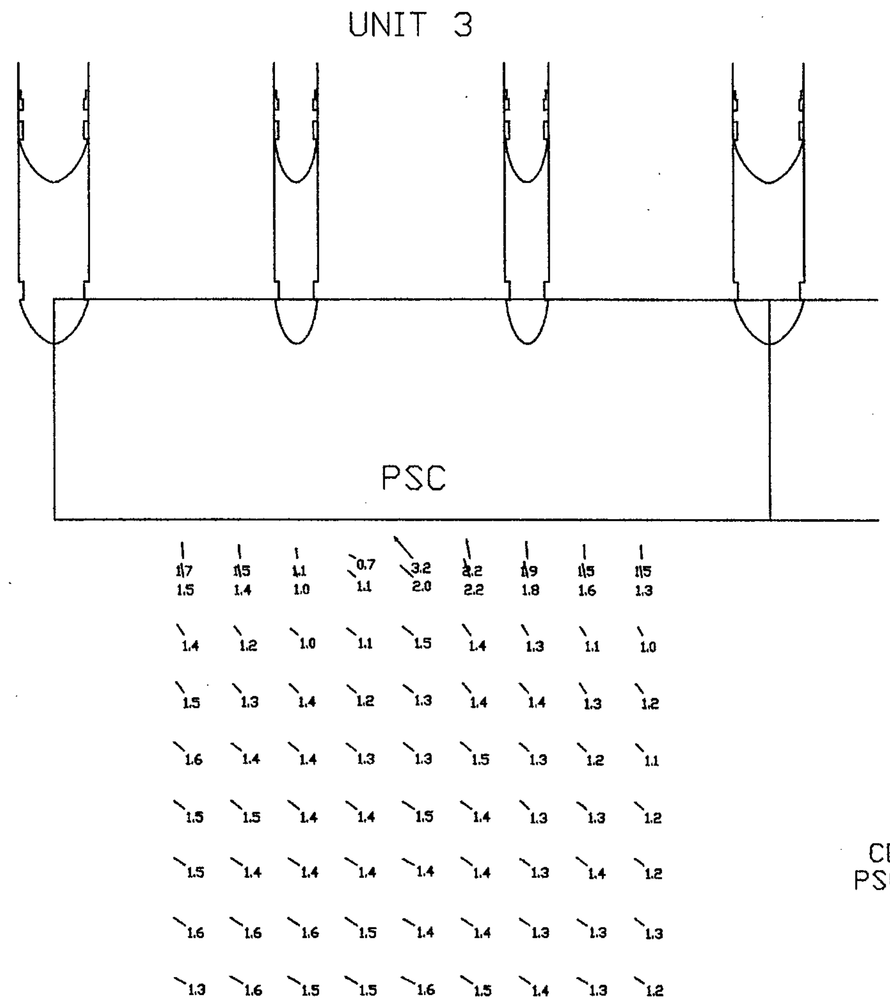
COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5   POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 4 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 12



COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 6 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 13

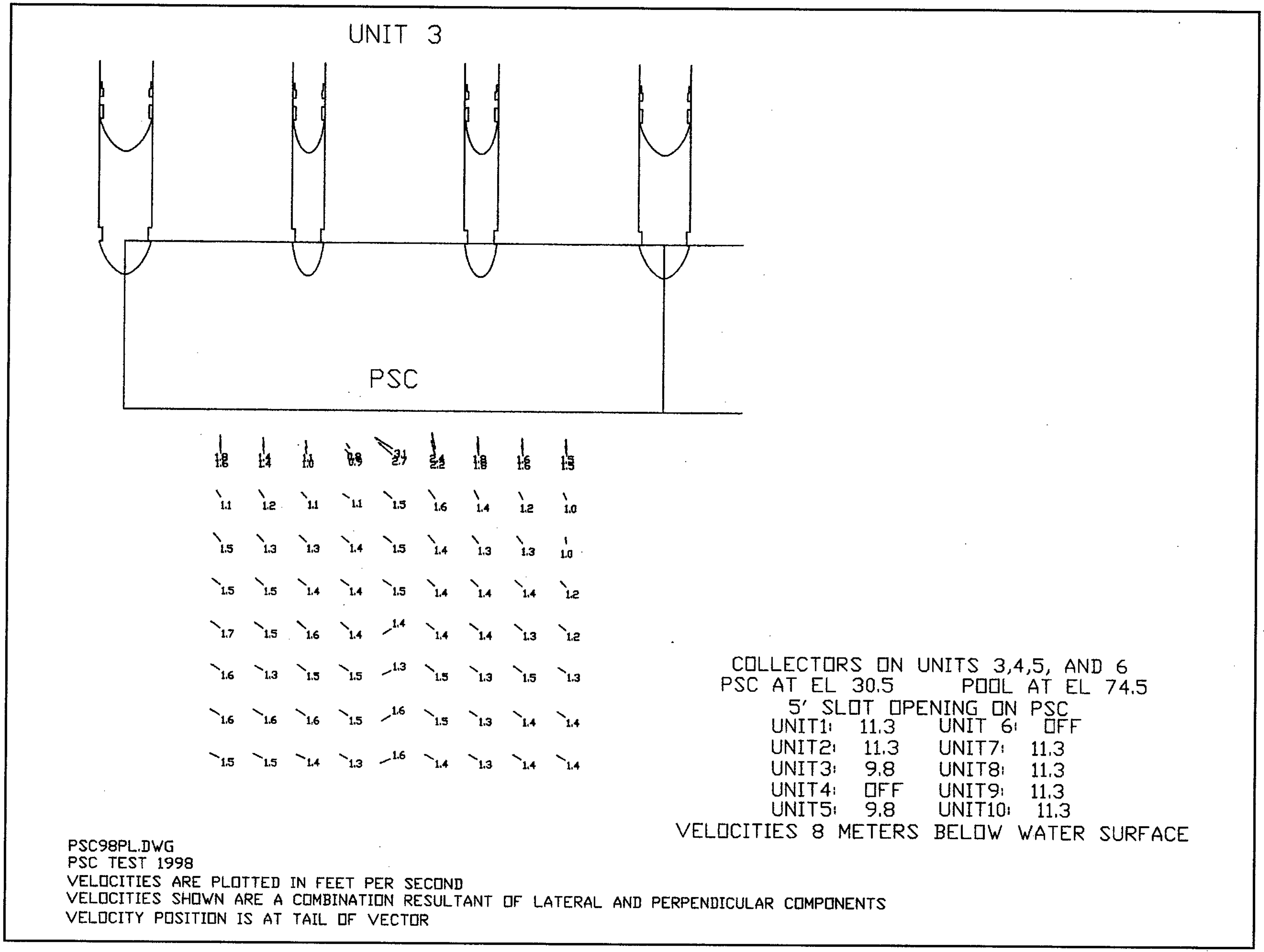
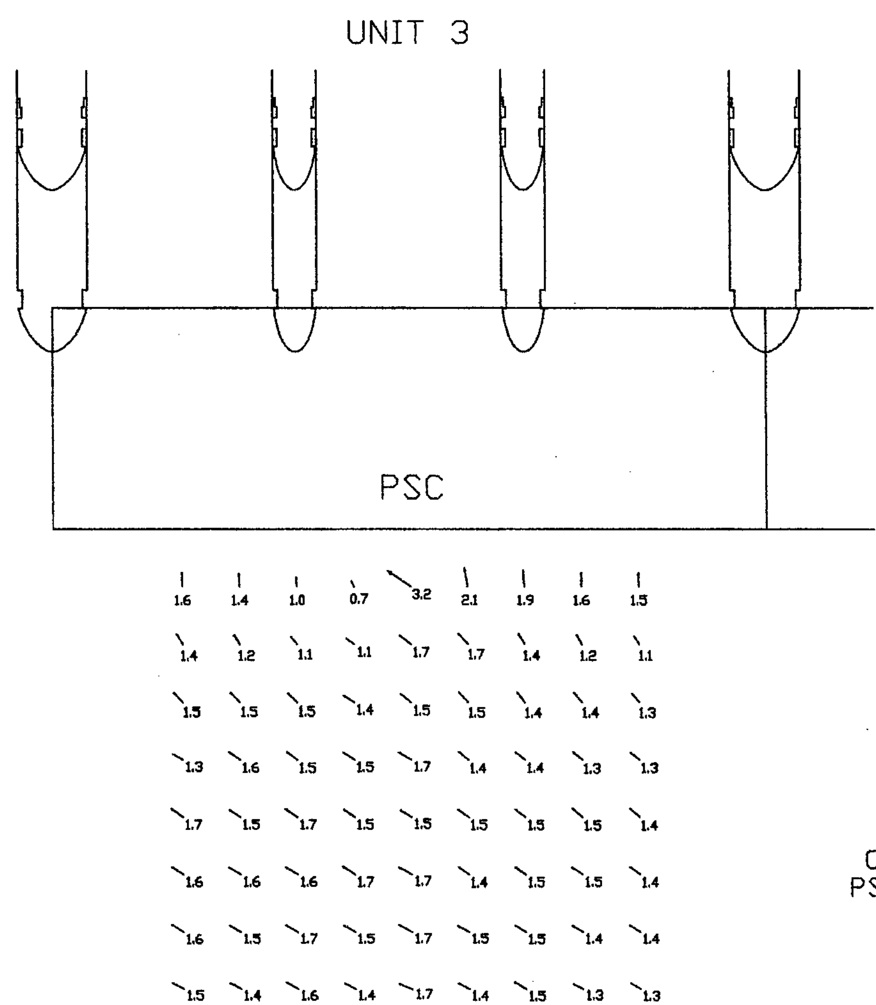

UNIT 3
PSC
COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC
UNIT1: 11.3 UNIT 6: OFF
UNIT2: 11.3 UNIT7: 11.3
UNIT3: 9.8 UNIT8: 11.3
UNIT4: OFF UNIT9: 11.3
UNIT5: 9.8 UNIT10: 11.3
VELOCITIES 8 METERS BELOW WATER SURFACE
PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 14

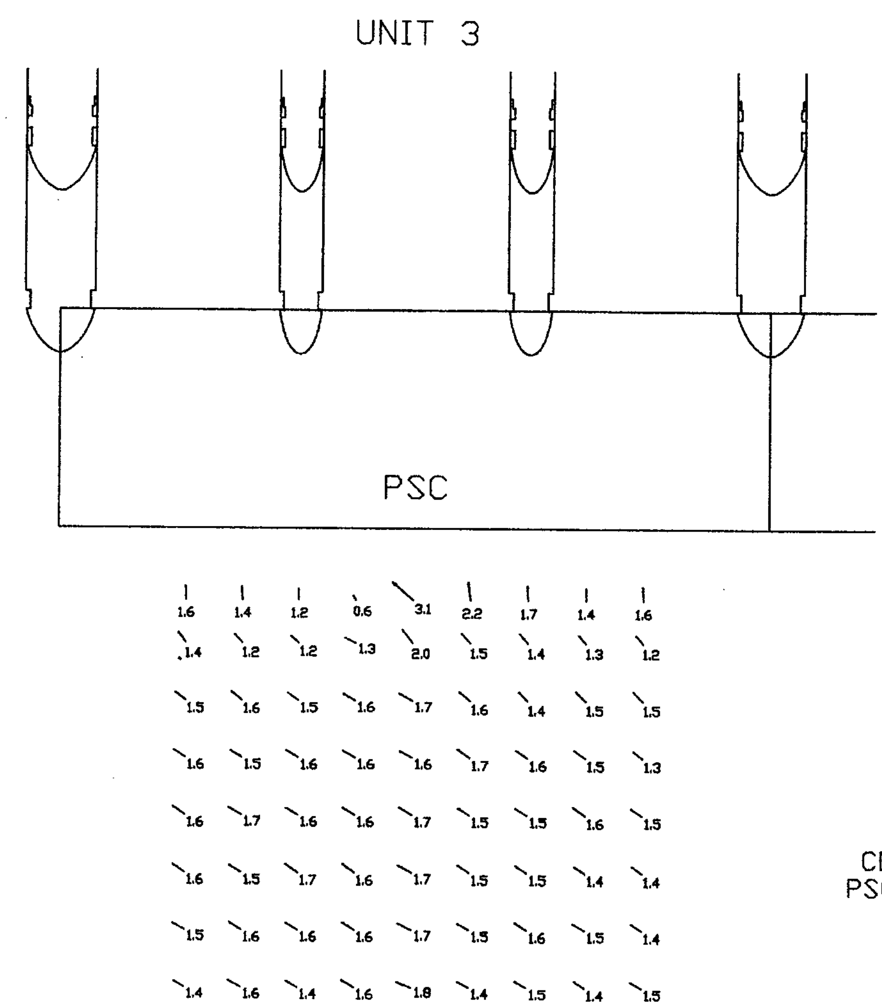


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5   POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 10 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR



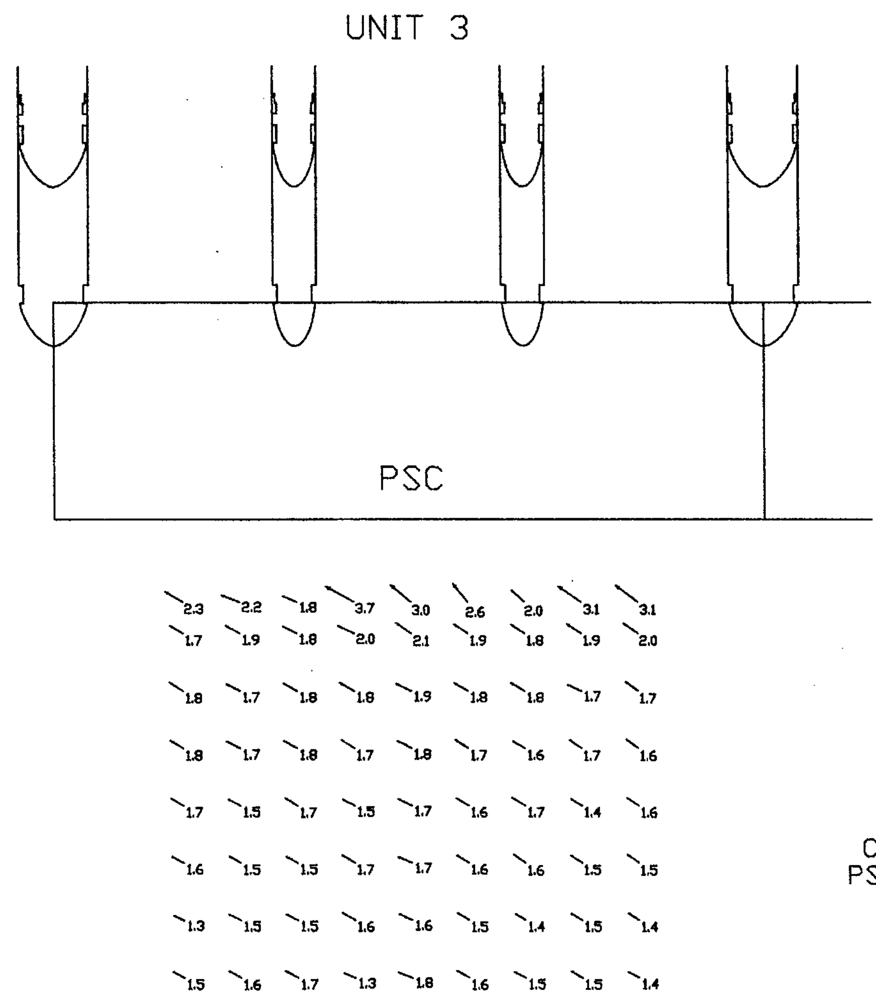
COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 12 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 16



COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 14 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

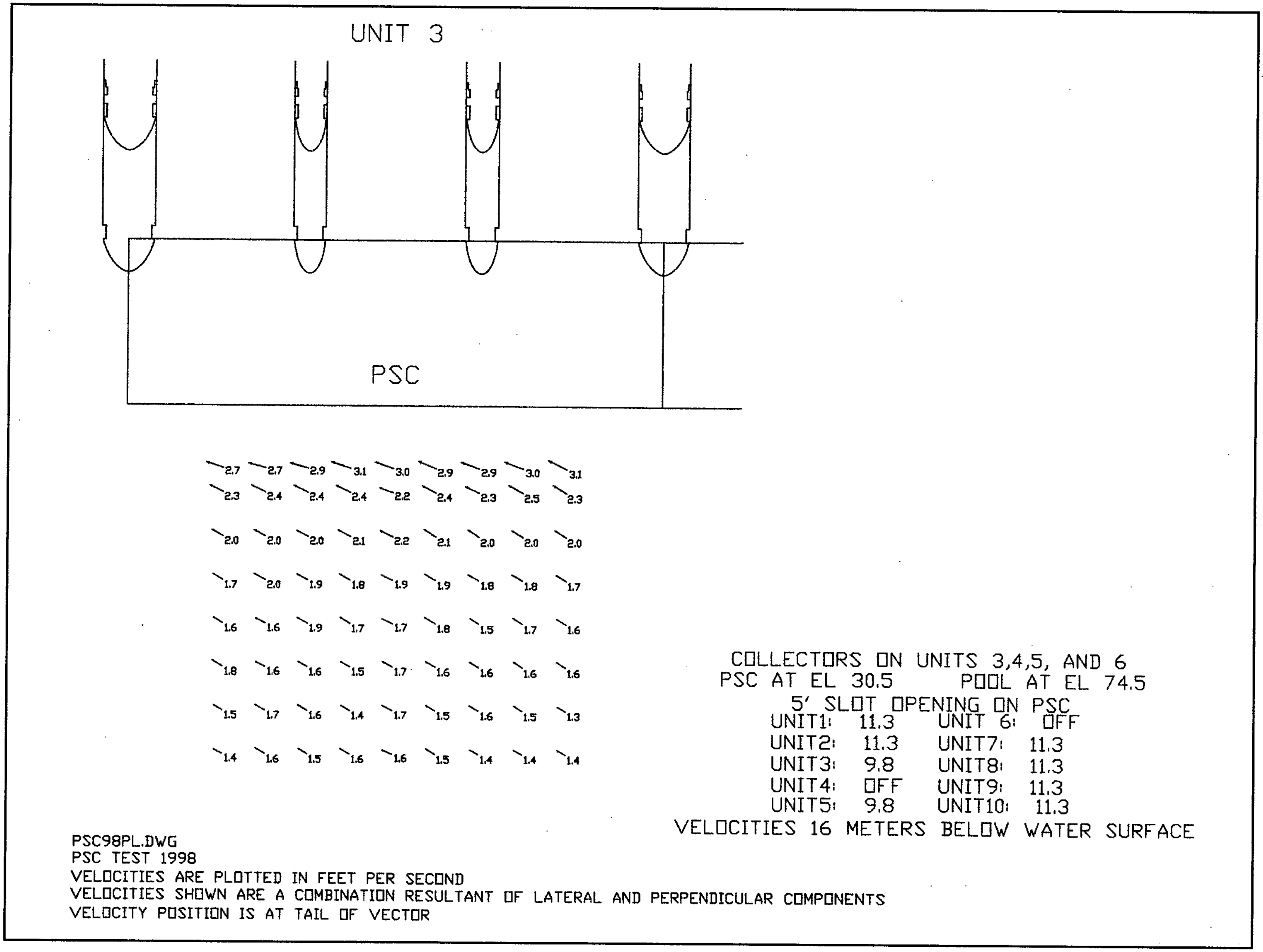
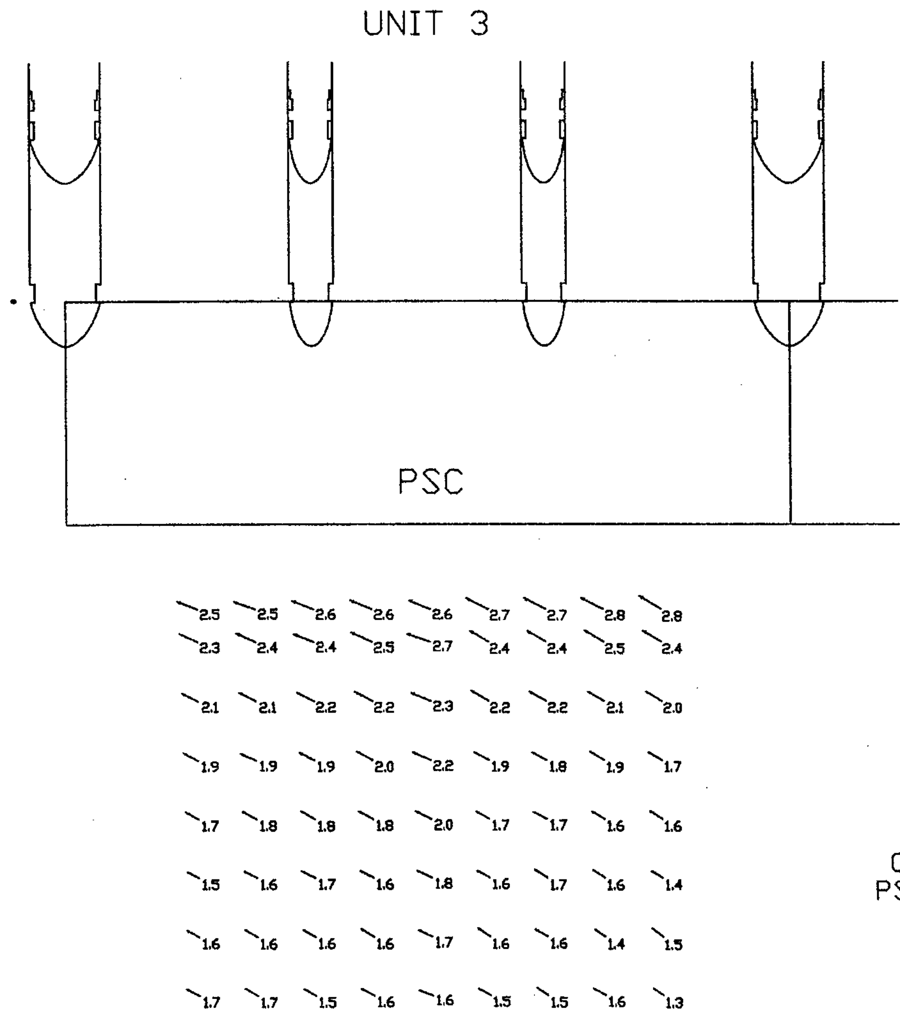

UNIT 3
PSC
2.7 2.7 2.9 3.1 3.0 2.9 2.9 3.0 3.1
2.3 2.4 2.4 2.4 2.2 2.4 2.3 2.5 2.3
2.0 2.0 2.0 2.1 2.2 2.1 2.0 2.0 2.0
1.7 2.0 1.9 1.8 1.9 1.9 1.8 1.8 1.7
1.6 1.6 1.9 1.7 1.7 1.8 1.5 1.7 1.6
1.8 1.6 1.6 1.5 1.7 1.6 1.6 1.6 1.6
1.5 1.7 1.6 1.4 1.7 1.5 1.6 1.5 1.3
1.4 1.6 1.5 1.6 1.6 1.5 1.4 1.4 1.4
COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC
UNIT1: 11.3 UNIT 6: OFF
UNIT2: 11.3 UNIT7: 11.3
UNIT3: 9.8 UNIT8: 11.3
UNIT4: OFF UNIT9: 11.3
UNIT5: 9.8 UNIT10: 11.3
VELOCITIES 16 METERS BELOW WATER SURFACE
PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 18



COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 18 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

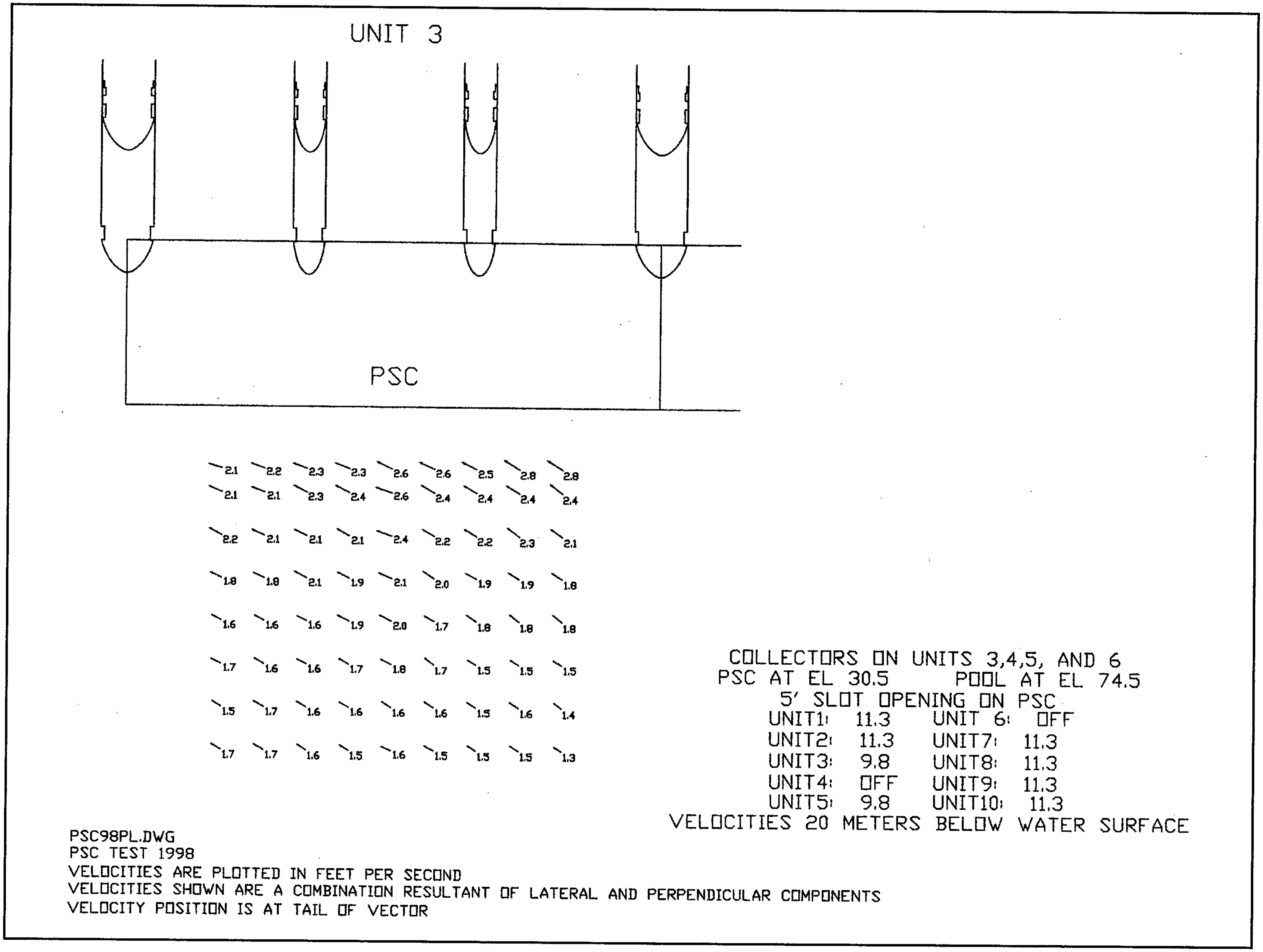
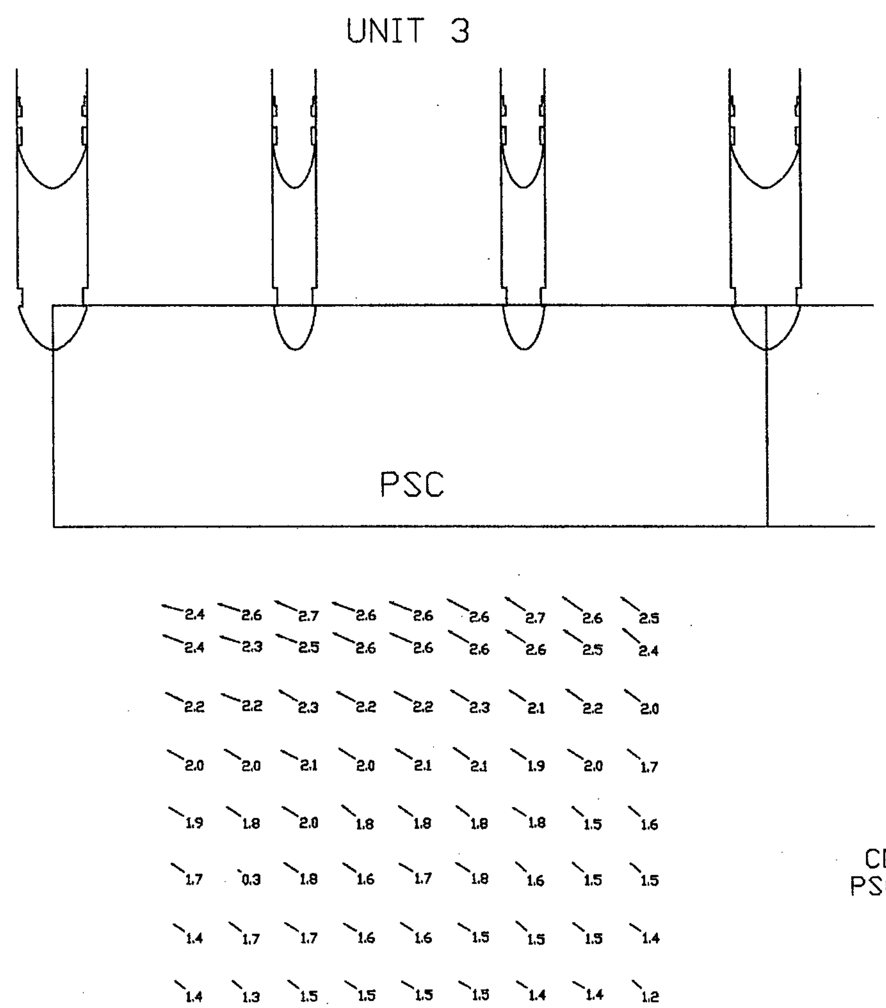

UNIT 3
PSC
2.1 2.2 2.3 2.3 2.6 2.6 2.5 2.8 2.8
2.1 2.1 2.3 2.4 2.6 2.4 2.4 2.4 2.4
2.2 2.1 2.1 2.1 2.4 2.2 2.2 2.3 2.1
1.8 1.8 2.1 1.9 2.1 2.0 1.9 1.9 1.8
1.6 1.6 1.6 1.9 2.0 1.7 1.8 1.8 1.8
1.7 1.6 1.6 1.7 1.8 1.7 1.5 1.5 1.5
1.5 1.7 1.6 1.6 1.6 1.6 1.5 1.6 1.4
1.7 1.7 1.6 1.5 1.6 1.5 1.5 1.5 1.3
COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC
UNIT1: 11.3 UNIT 6: OFF
UNIT2: 11.3 UNIT7: 11.3
UNIT3: 9.8 UNIT8: 11.3
UNIT4: OFF UNIT9: 11.3
UNIT5: 9.8 UNIT10: 11.3
VELOCITIES 20 METERS BELOW WATER SURFACE
PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 20

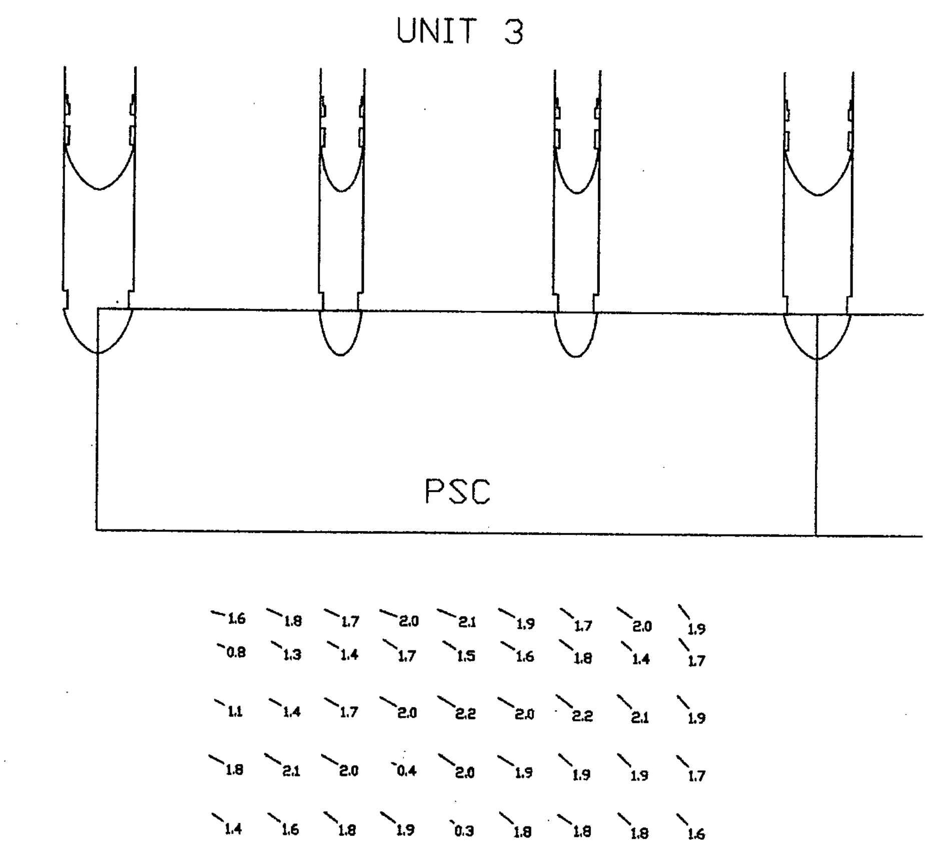


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 22 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

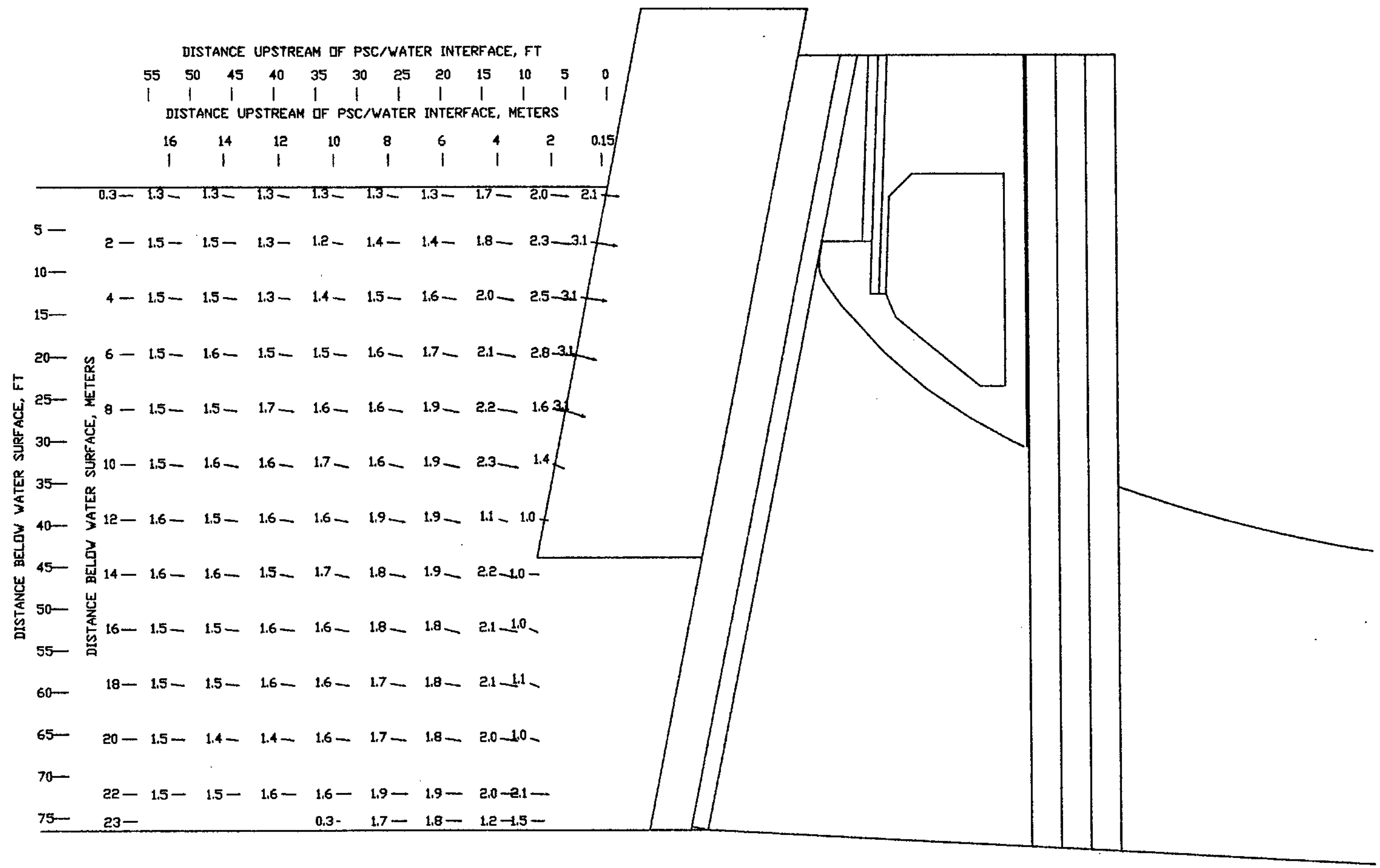


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
5' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 23 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

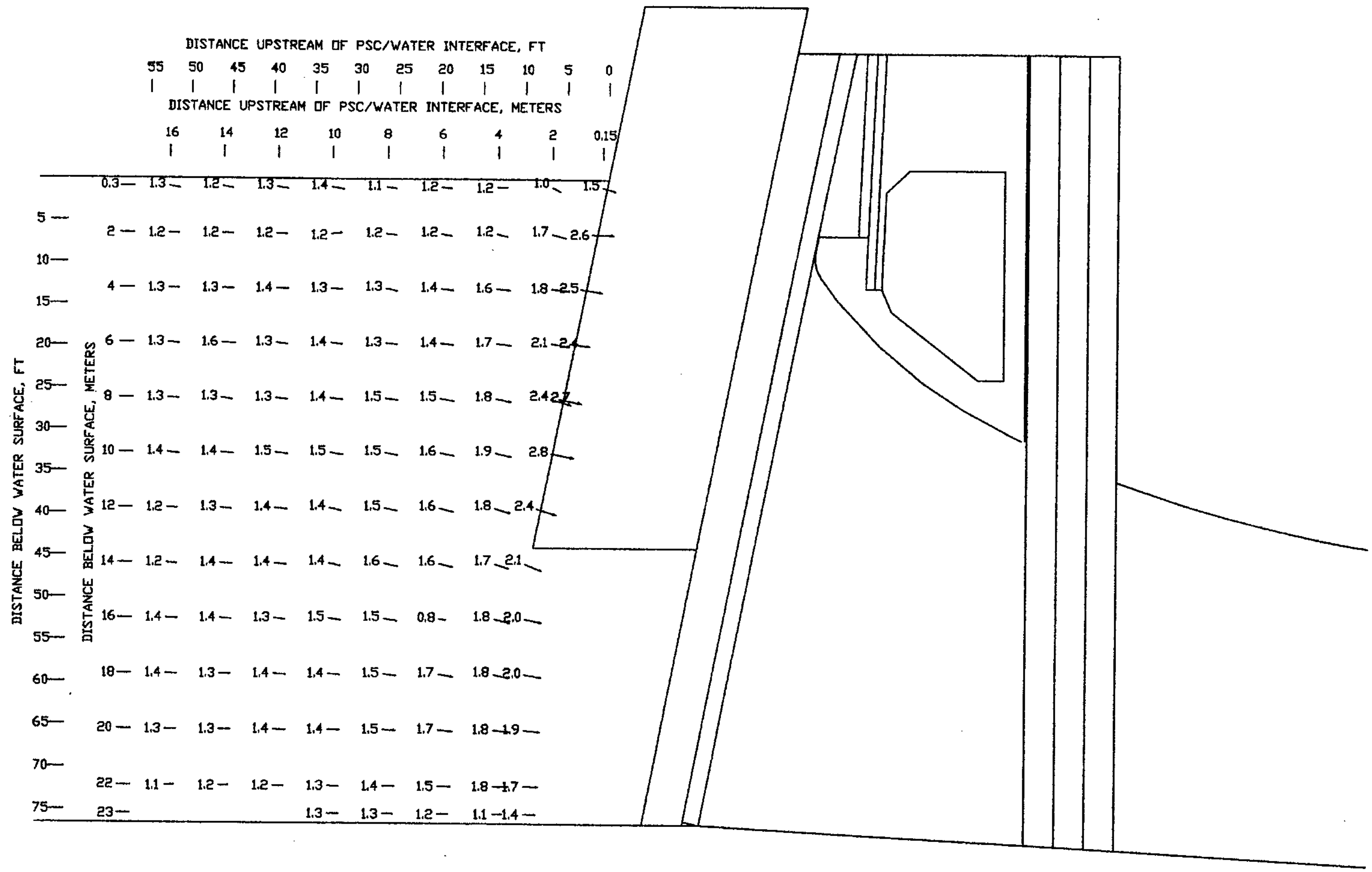


UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
20' SLOT OPENING ON PSC
VELOCITIES OBTAINED ALONG CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 23

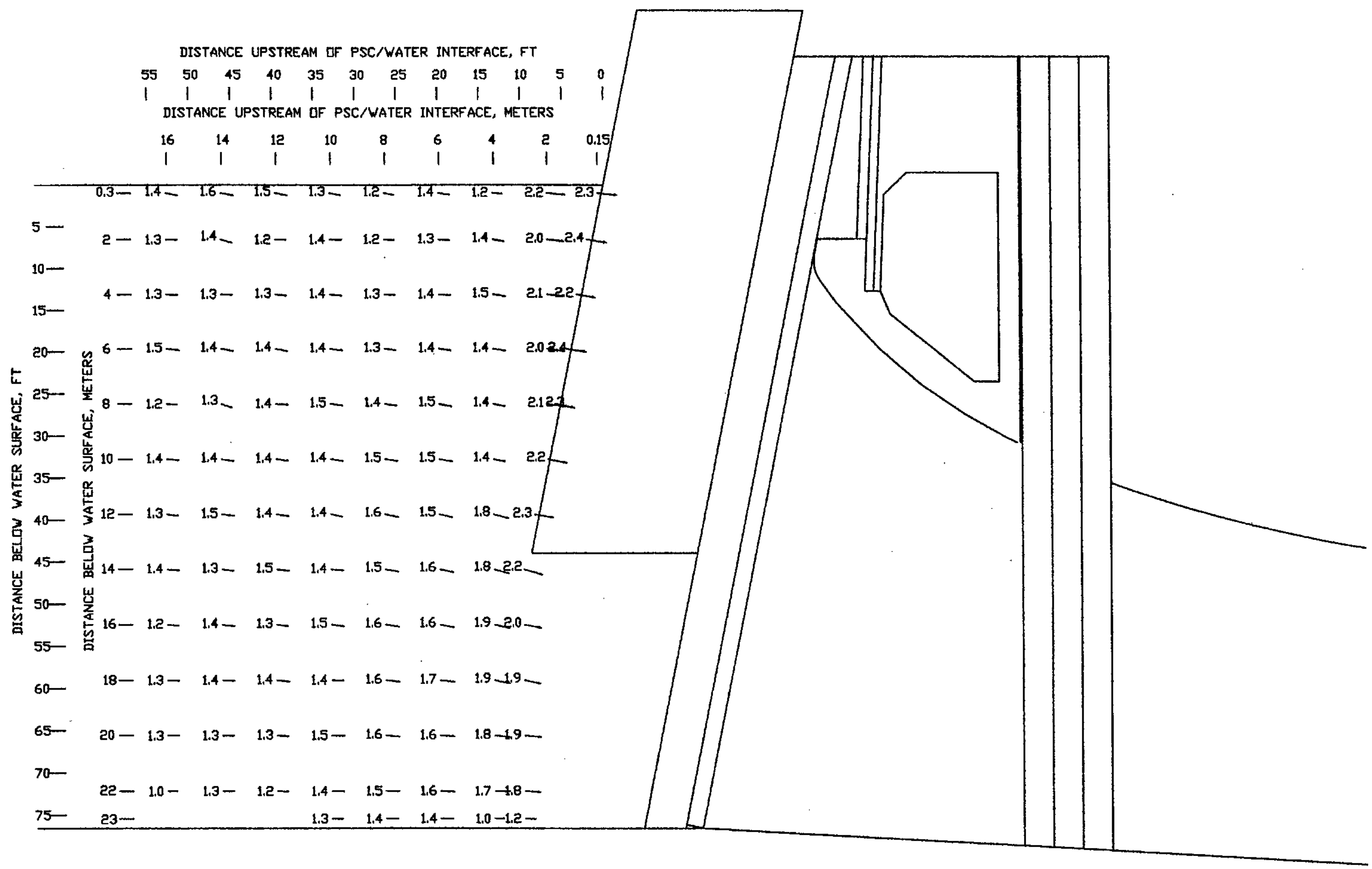


UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
20' SLOT OPENING ON PSC
VELOCITIES OBTAINED 2 METERS LEFT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

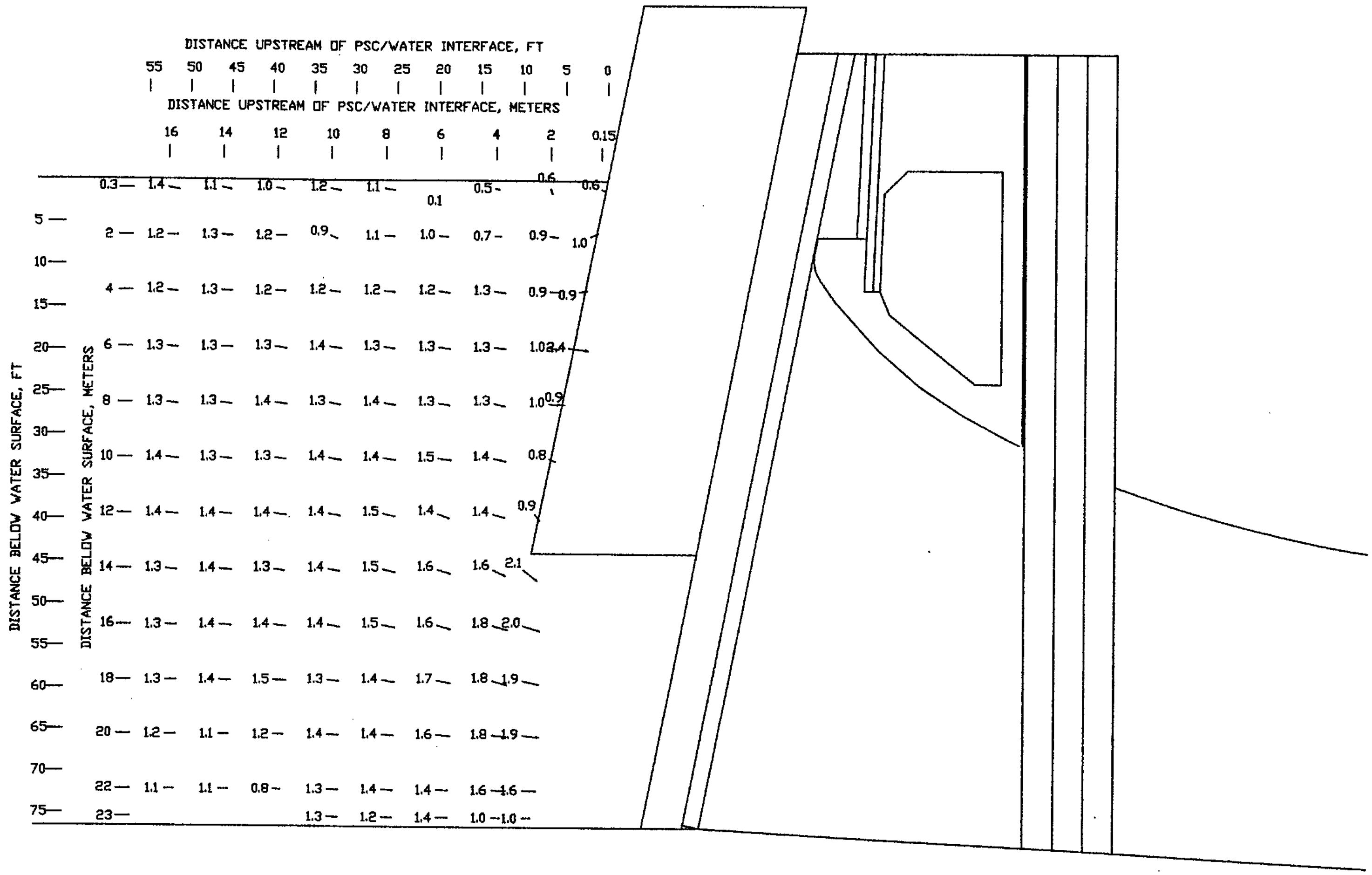
Plate 24



UNIT1:	11.3kcfs	UNIT6:	OFF
UNIT2:	11.3kcfs	UNIT7:	11.3kcfs
UNIT3:	9.8kcfs	UNIT8:	11.3kcfs
UNIT4:	OFF	UNIT9:	11.3kcfs
UNIT5:	9.8kcfs	UNIT10:	11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
20' SLOT OPENING ON PSC
VELOCITIES OBTAINED 2 METERS RIGHT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

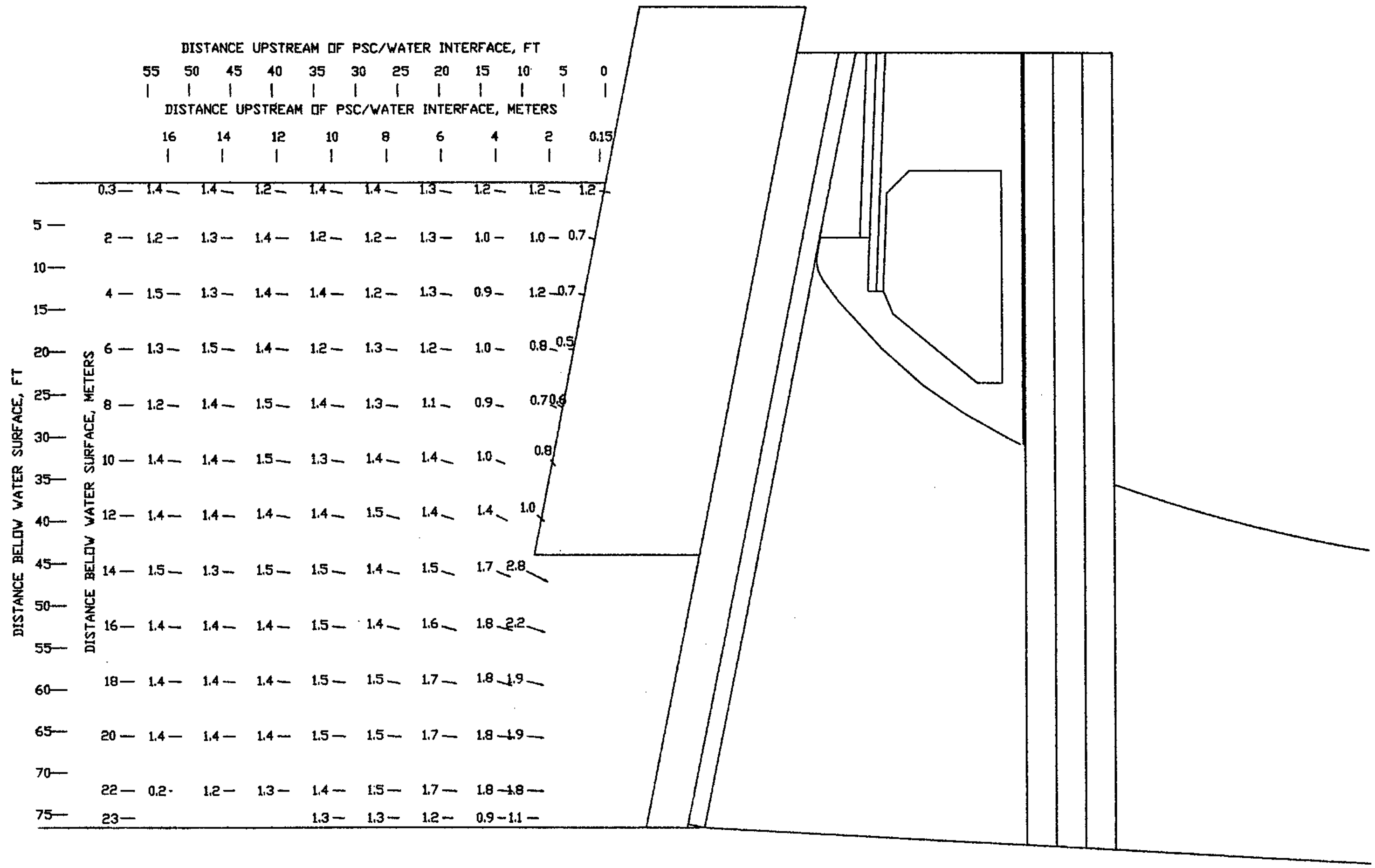


UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
20' SLOT OPENING ON PSC
VELOCITIES OBTAINED 4 METERS LEFT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 26

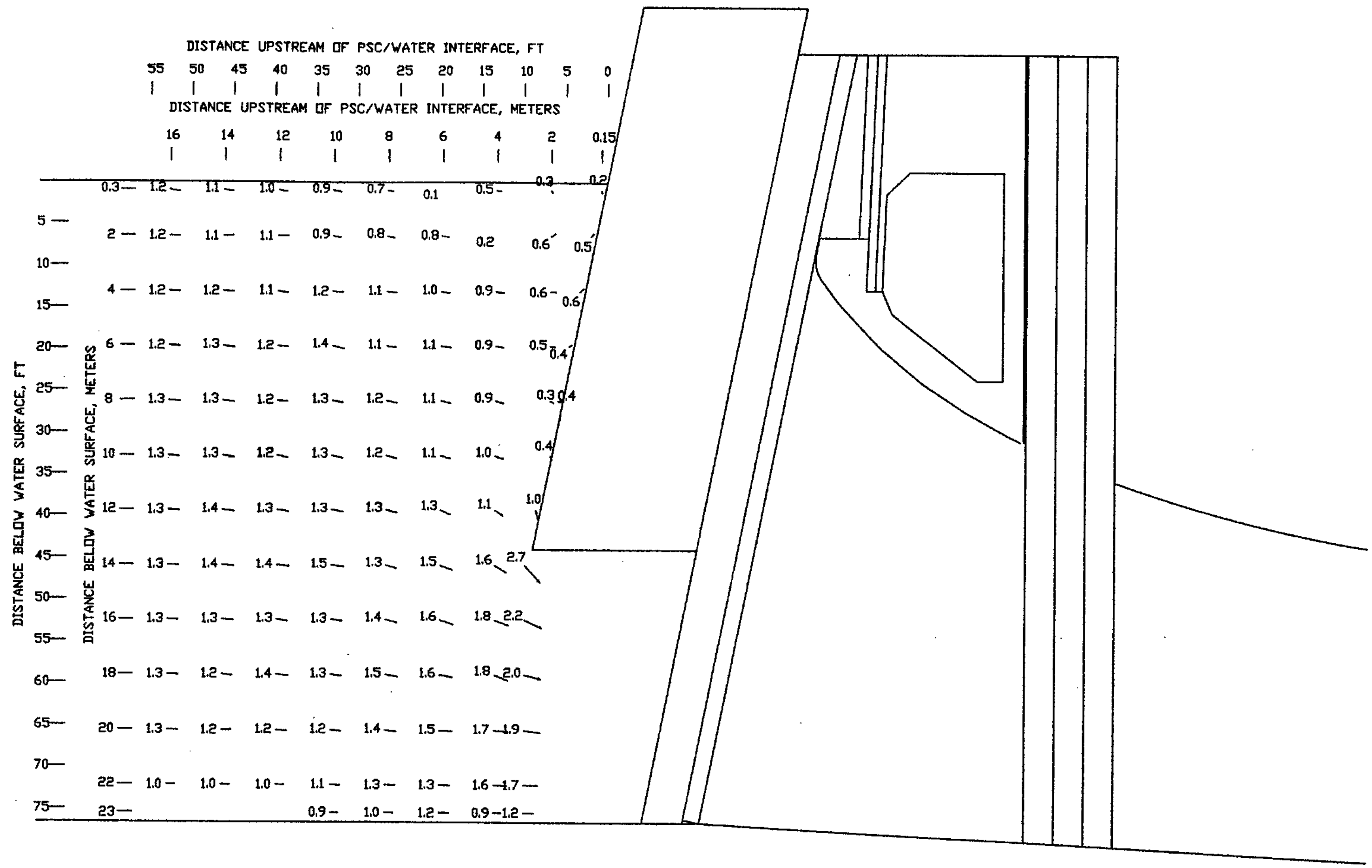


UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
20' SLOT OPENING ON PSC
VELOCITIES OBTAINED 4 METERS RIGHT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

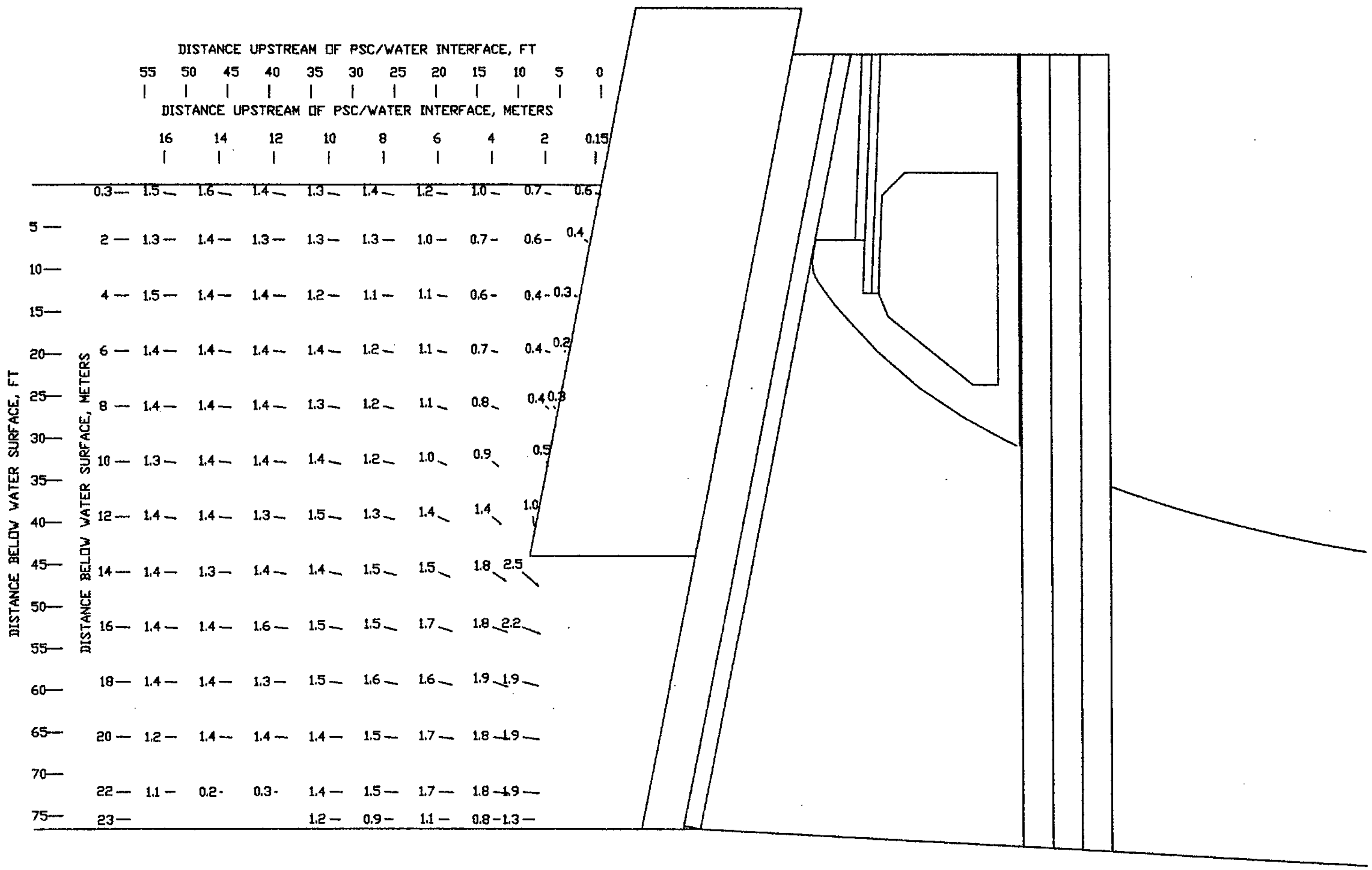
Plate 28



UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
20' SLOT OPENING ON PSC
VELOCITIES OBTAINED 6 METERS LEFT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR



UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
20' SLOT OPENING ON PSC
VELOCITIES OBTAINED 6 METERS RIGHT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

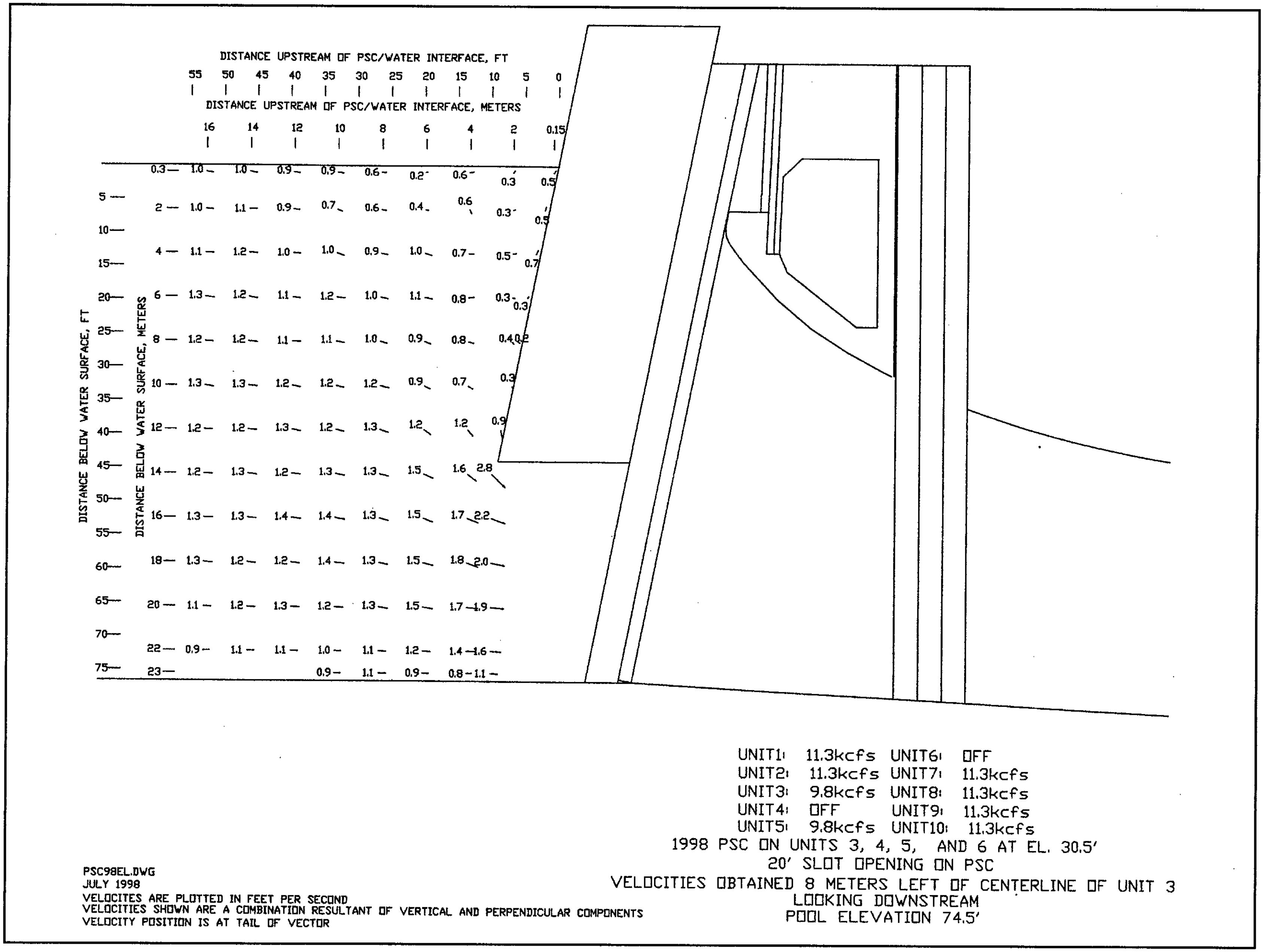
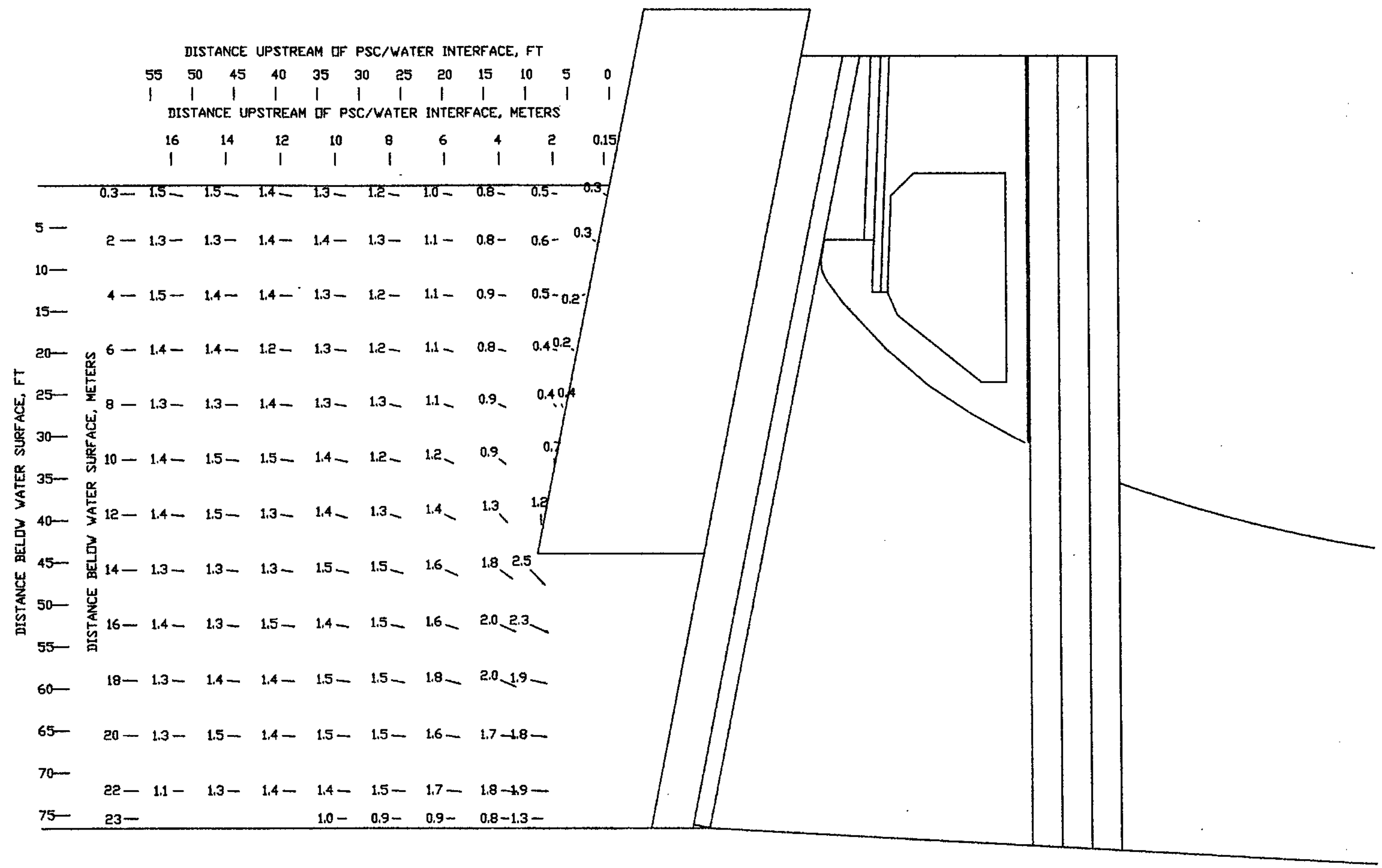

DISTANCE UPSTREAM OF PSC/WATER INTERFACE, FT
55 50 45 40 35 30 25 20 15 10 5 0
DISTANCE UPSTREAM OF PSC/WATER INTERFACE, METERS
16 14 12 10 8 6 4 2 0.15
DISTANCE BELOW WATER SURFACE, FT
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
DISTANCE BELOW WATER SURFACE, METERS
0.3 1.0 1.0 0.9 0.9 0.6 0.2 0.6 0.3 0.5
2 1.0 1.1 0.9 0.7 0.6 0.4 0.6 0.3 0.5
4 1.1 1.2 1.0 1.0 0.9 1.0 0.7 0.5 0.7
6 1.3 1.2 1.1 1.2 1.0 1.1 0.8 0.3 0.3
8 1.2 1.2 1.1 1.1 1.0 0.9 0.8 0.4 0.2
10 1.3 1.3 1.2 1.2 1.2 0.9 0.7 0.3
12 1.2 1.2 1.3 1.2 1.3 1.2 1.2 0.9
14 1.2 1.3 1.2 1.3 1.3 1.5 1.6 2.8
16 1.3 1.3 1.4 1.4 1.3 1.5 1.7 2.2
18 1.3 1.2 1.2 1.4 1.3 1.5 1.8 2.0
20 1.1 1.2 1.3 1.2 1.3 1.5 1.7 1.9
22 0.9 1.1 1.1 1.0 1.1 1.2 1.4 1.6
23 0.9 1.1 0.9 0.8 1.1
UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs
1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
20' SLOT OPENING ON PSC
VELOCITIES OBTAINED 8 METERS LEFT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'
PSC98EL.DWG
JULY 1998
VELOCITES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

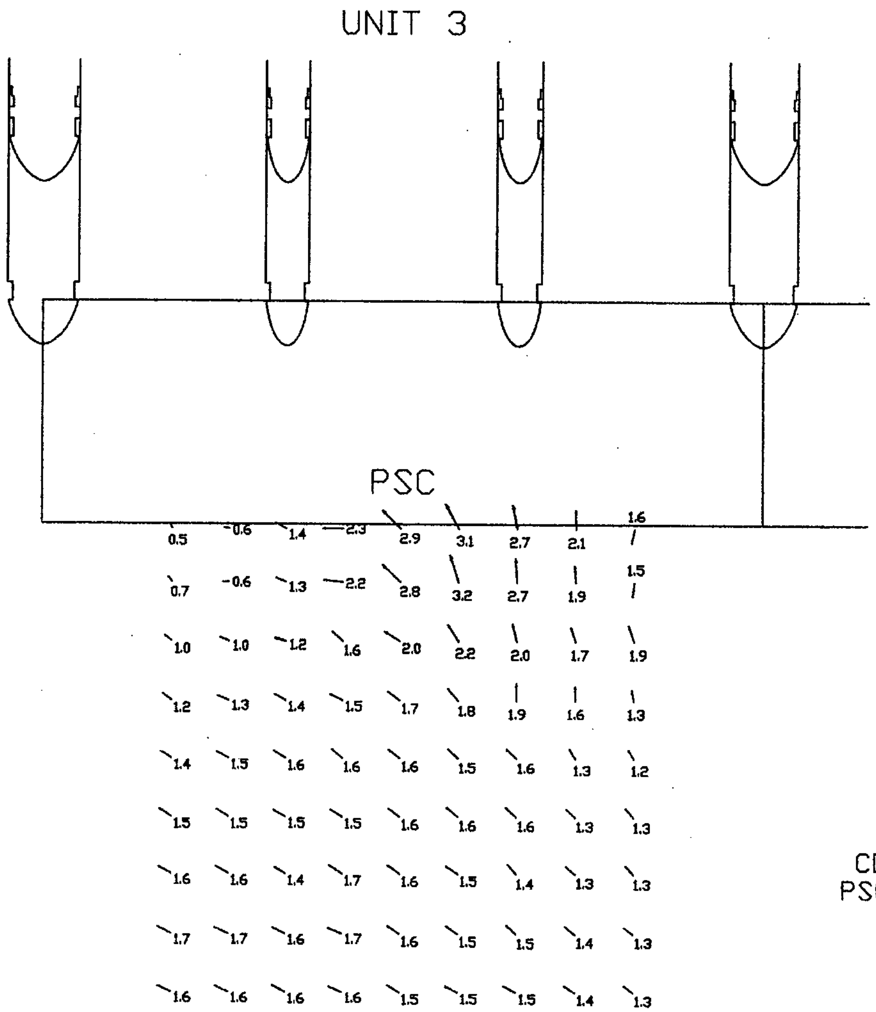
Plate 30



UNIT1: 11.3kcfs UNIT6: OFF
UNIT2: 11.3kcfs UNIT7: 11.3kcfs
UNIT3: 9.8kcfs UNIT8: 11.3kcfs
UNIT4: OFF UNIT9: 11.3kcfs
UNIT5: 9.8kcfs UNIT10: 11.3kcfs

1998 PSC ON UNITS 3, 4, 5, AND 6 AT EL. 30.5'
20' SLOT OPENING ON PSC
VELOCITIES OBTAINED 8 METERS RIGHT OF CENTERLINE OF UNIT 3
LOOKING DOWNSTREAM
POOL ELEVATION 74.5'

PSC98EL.DWG
JULY 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF VERTICAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

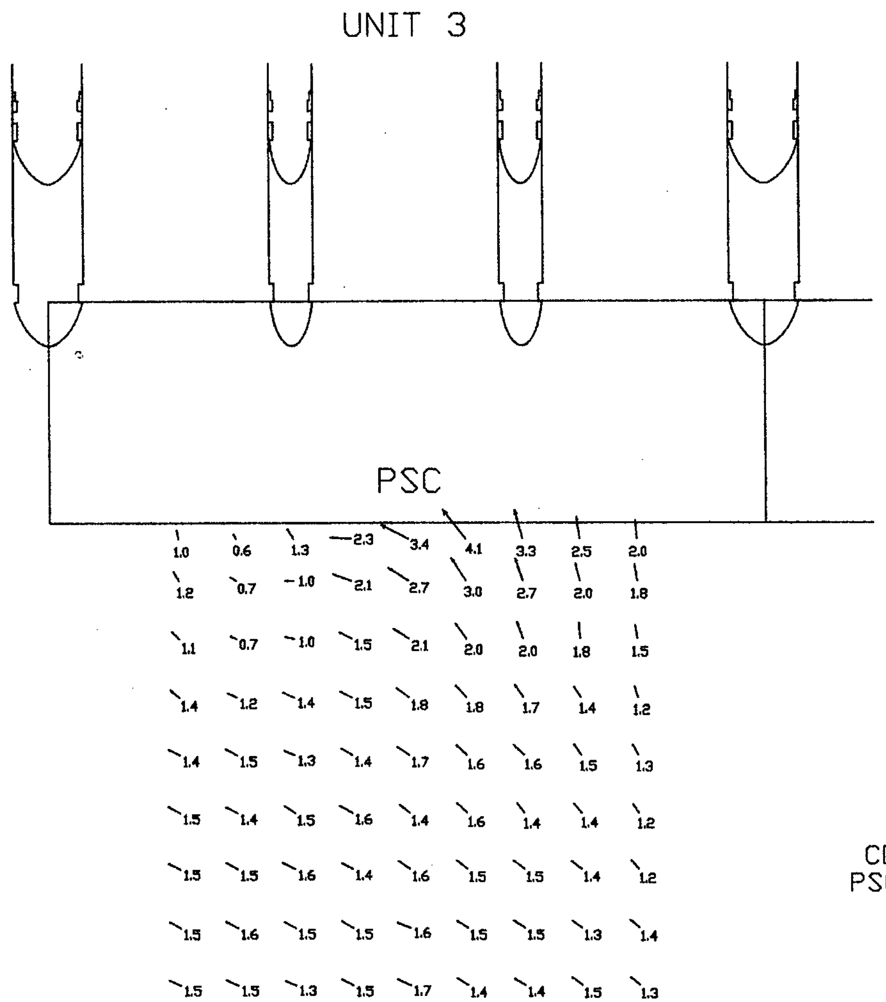


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 0.3 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

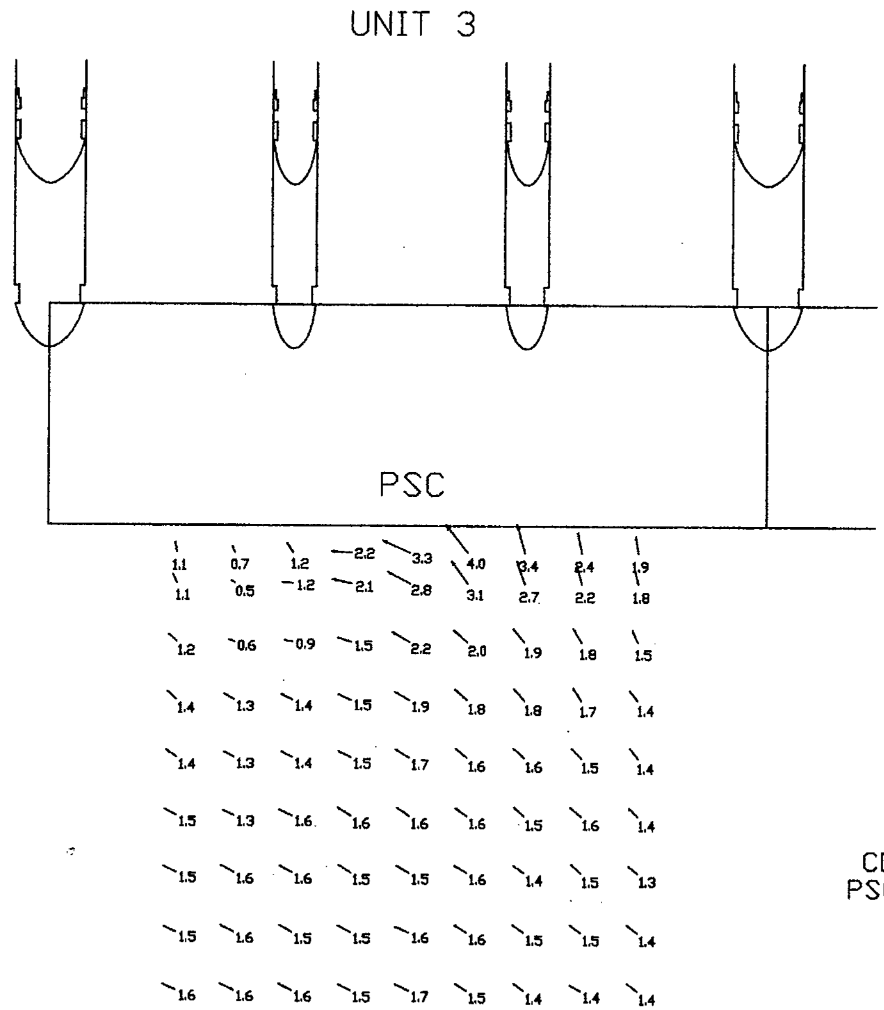


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5   POOL AT EL 74.5
20' SLOT OPENING ON PSC

UNIT1: 11.3	UNIT 6: OFF
UNIT2: 11.3	UNIT7: 11.3
UNIT3: 9.8	UNIT8: 11.3
UNIT4: OFF	UNIT9: 11.3
UNIT5: 9.8	UNIT10: 11.3

VELOCITIES 2 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

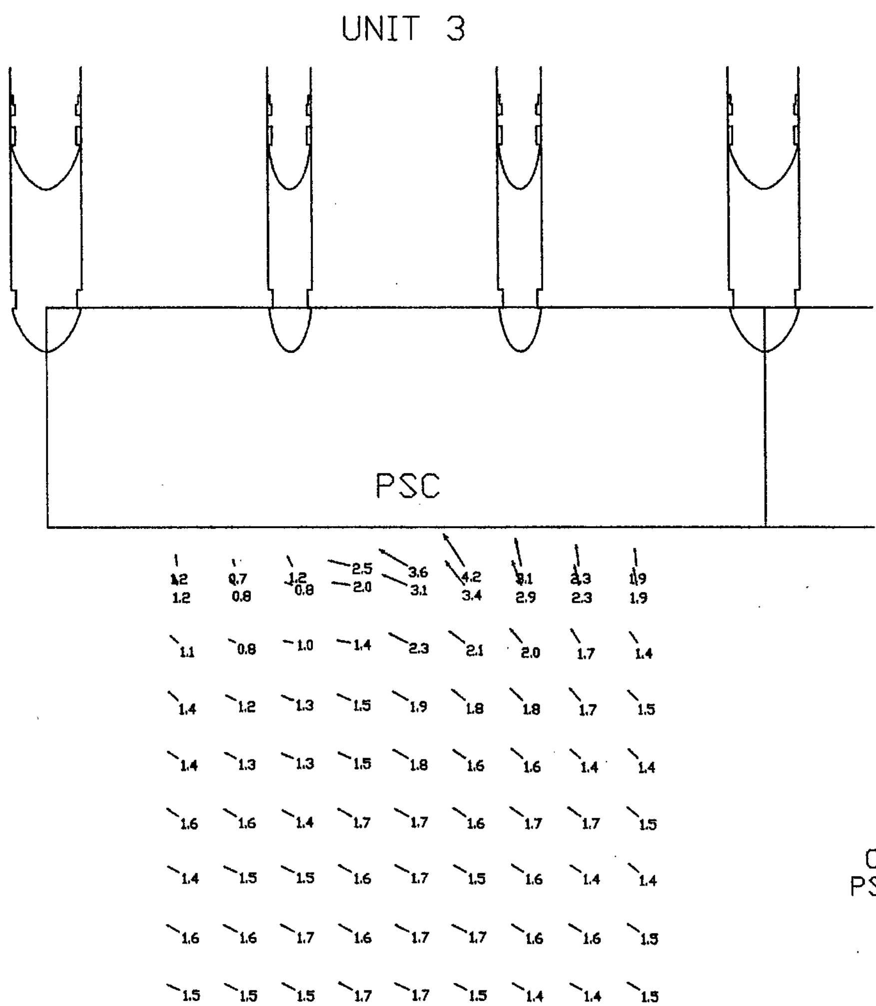


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 4 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

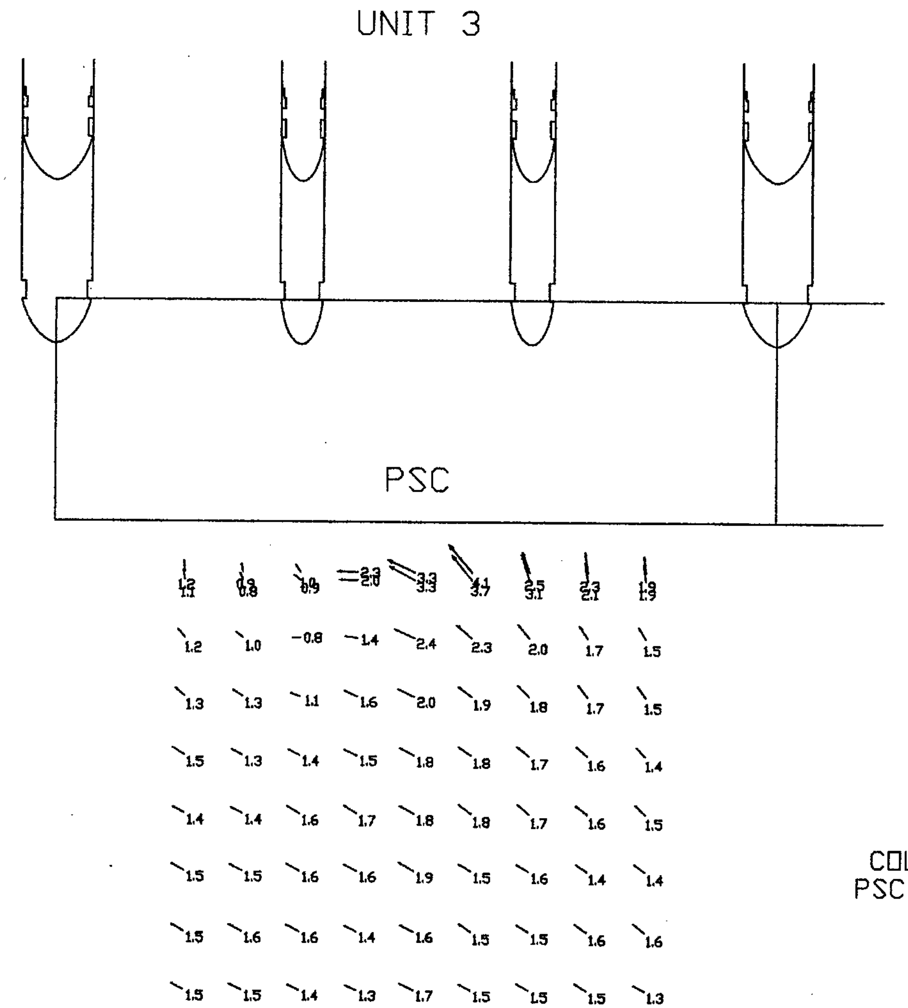


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 6 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

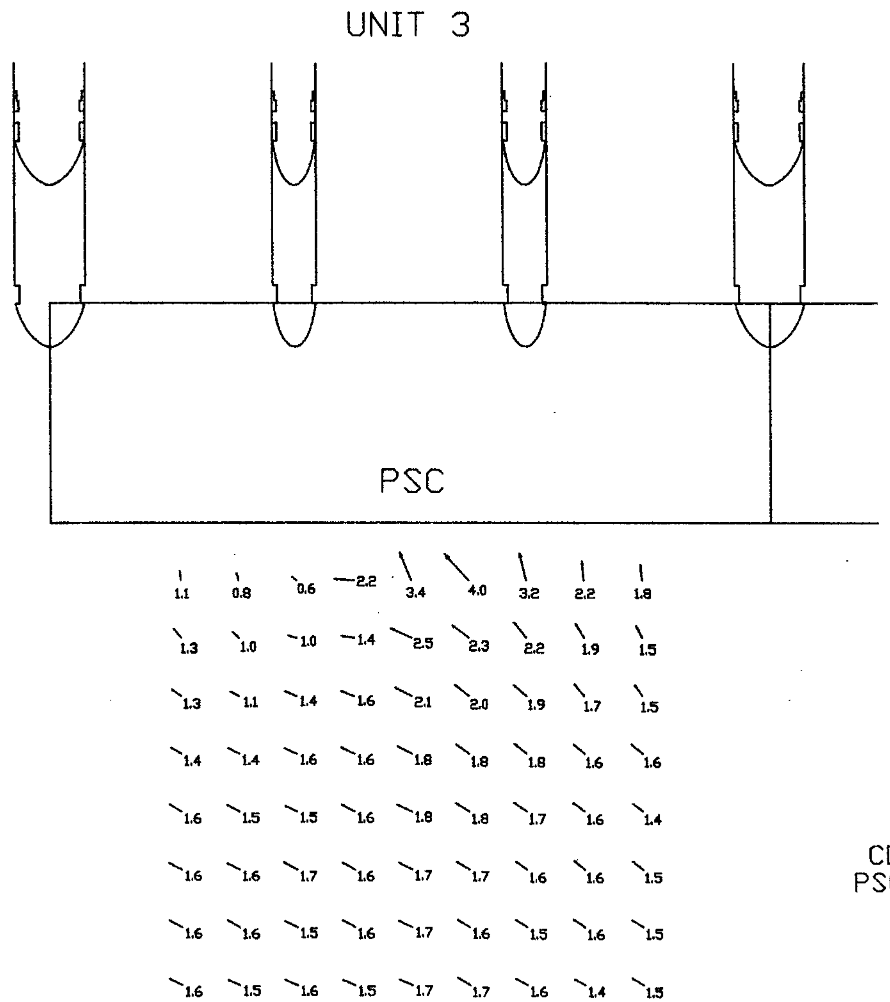


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 8 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR



COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITES 10 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

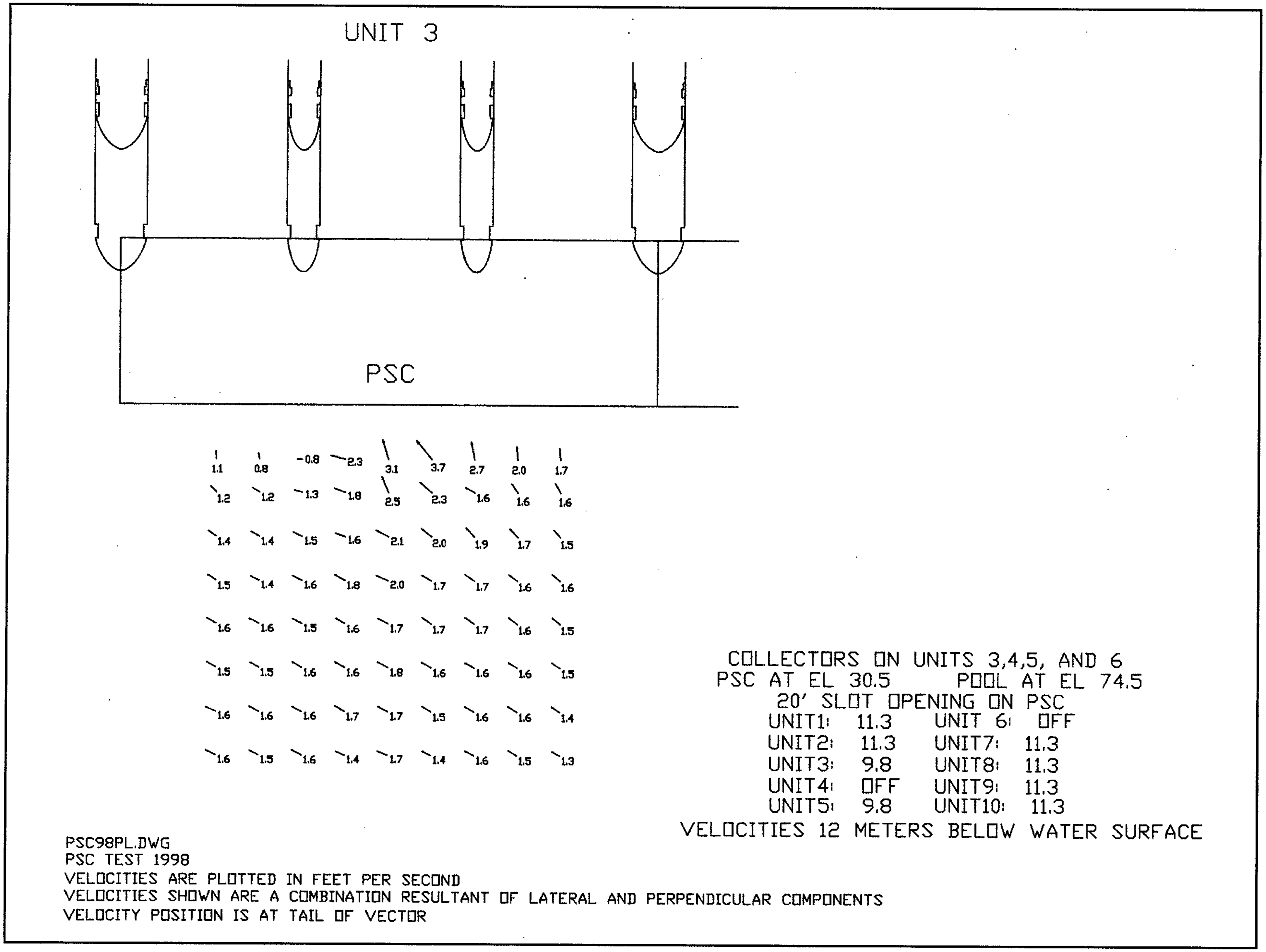

UNIT 3
PSC
1.1 0.8 -0.8 2.3 3.1 3.7 2.7 2.0 1.7
1.2 1.2 1.3 1.8 2.5 2.3 1.6 1.6 1.6
1.4 1.4 1.5 1.6 2.1 2.0 1.9 1.7 1.5
1.5 1.4 1.6 1.8 2.0 1.7 1.7 1.6 1.6
1.6 1.6 1.5 1.6 1.7 1.7 1.7 1.6 1.5
1.5 1.5 1.6 1.6 1.8 1.6 1.6 1.6 1.5
1.6 1.6 1.6 1.7 1.7 1.5 1.6 1.6 1.4
1.6 1.5 1.6 1.4 1.7 1.4 1.6 1.5 1.3
COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC
UNIT1: 11.3 UNIT 6: OFF
UNIT2: 11.3 UNIT7: 11.3
UNIT3: 9.8 UNIT8: 11.3
UNIT4: OFF UNIT9: 11.3
UNIT5: 9.8 UNIT10: 11.3
VELOCITIES 12 METERS BELOW WATER SURFACE
PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 38

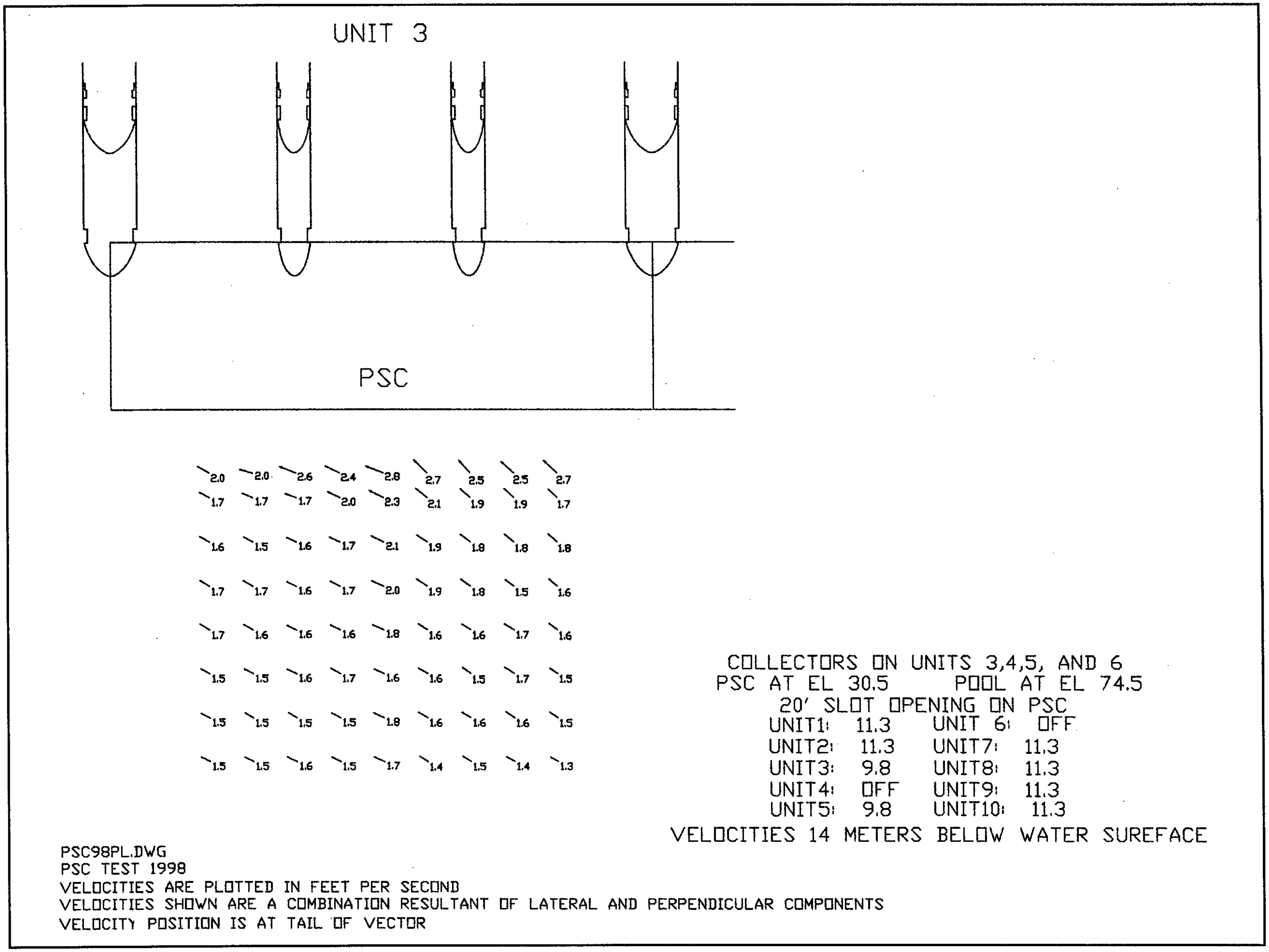

UNIT 3
PSC
2.0 2.0 2.6 2.4 2.8 2.7 2.5 2.5 2.7
1.7 1.7 1.7 2.0 2.3 2.1 1.9 1.9 1.7
1.6 1.5 1.6 1.7 2.1 1.9 1.8 1.8 1.8
1.7 1.7 1.6 1.7 2.0 1.9 1.8 1.5 1.6
1.7 1.6 1.6 1.6 1.8 1.6 1.6 1.7 1.6
1.5 1.5 1.6 1.7 1.6 1.6 1.5 1.7 1.5
1.5 1.5 1.5 1.5 1.8 1.6 1.6 1.6 1.5
1.5 1.5 1.6 1.5 1.7 1.4 1.5 1.4 1.3
COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC
UNIT1: 11.3 UNIT 6: OFF
UNIT2: 11.3 UNIT7: 11.3
UNIT3: 9.8 UNIT8: 11.3
UNIT4: OFF UNIT9: 11.3
UNIT5: 9.8 UNIT10: 11.3
VELOCITIES 14 METERS BELOW WATER SUREFACE
PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 39

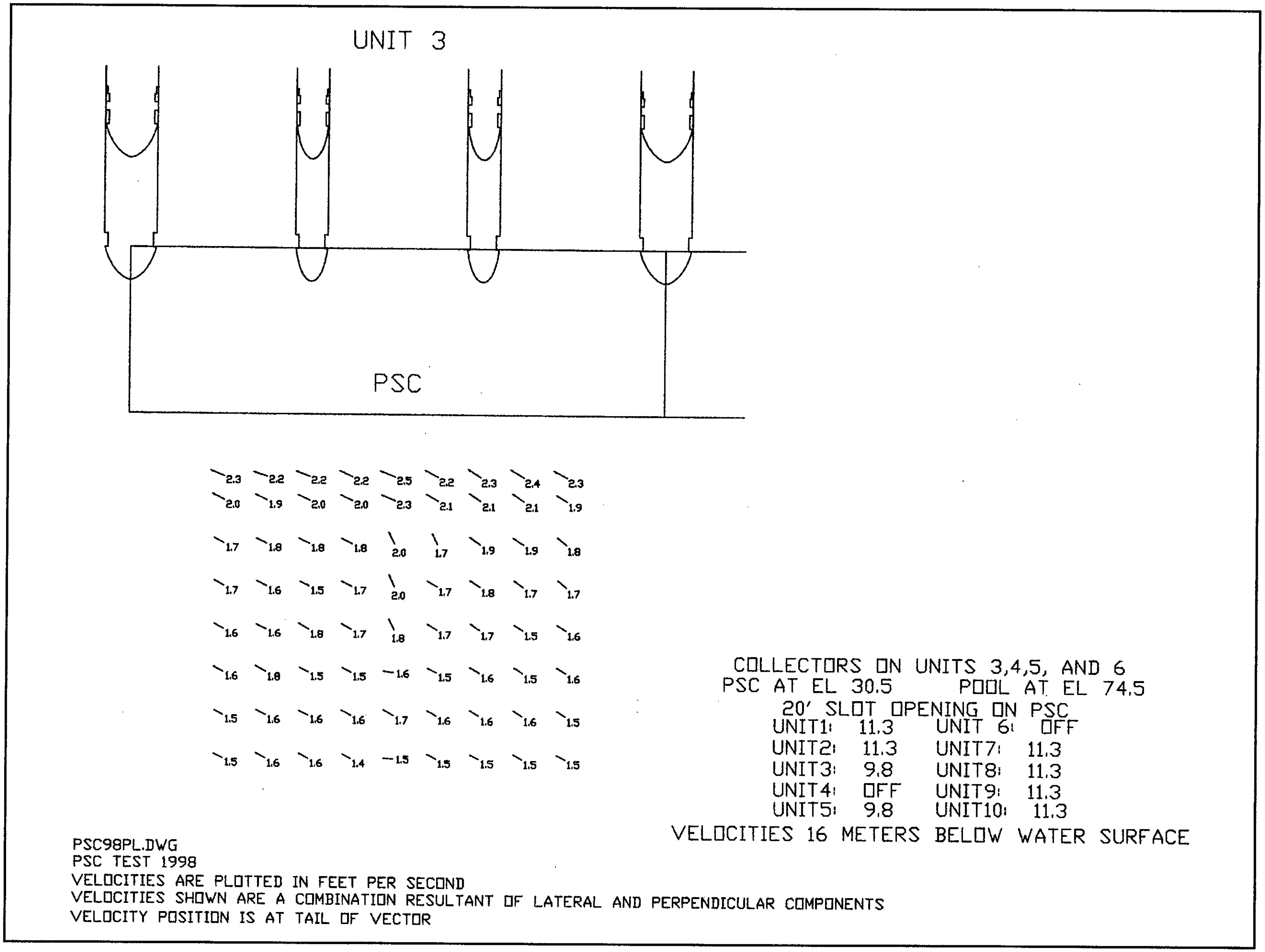
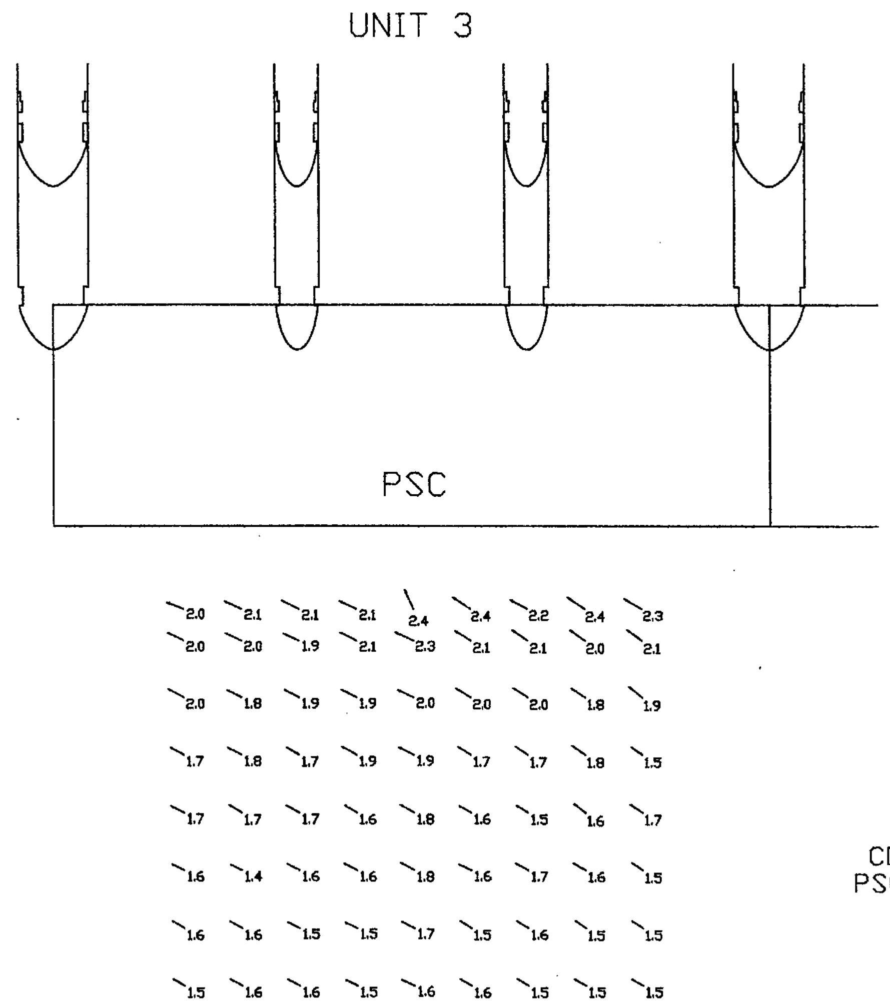

UNIT 3
PSC
2.3 2.2 2.2 2.2 2.5 2.2 2.3 2.4 2.3
2.0 1.9 2.0 2.0 2.3 2.1 2.1 2.1 1.9
1.7 1.8 1.8 1.8 2.0 1.7 1.9 1.9 1.8
1.7 1.6 1.5 1.7 2.0 1.7 1.8 1.7 1.7
1.6 1.6 1.8 1.7 1.8 1.7 1.7 1.5 1.6
1.6 1.8 1.5 1.5 1.6 1.5 1.6 1.5 1.6
1.5 1.6 1.6 1.6 1.7 1.6 1.6 1.6 1.5
1.5 1.6 1.6 1.4 1.5 1.5 1.5 1.5 1.5
COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC
UNIT1: 11.3 UNIT 6: OFF
UNIT2: 11.3 UNIT7: 11.3
UNIT3: 9.8 UNIT8: 11.3
UNIT4: OFF UNIT9: 11.3
UNIT5: 9.8 UNIT10: 11.3
VELOCITIES 16 METERS BELOW WATER SURFACE
PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 40



COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 18 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

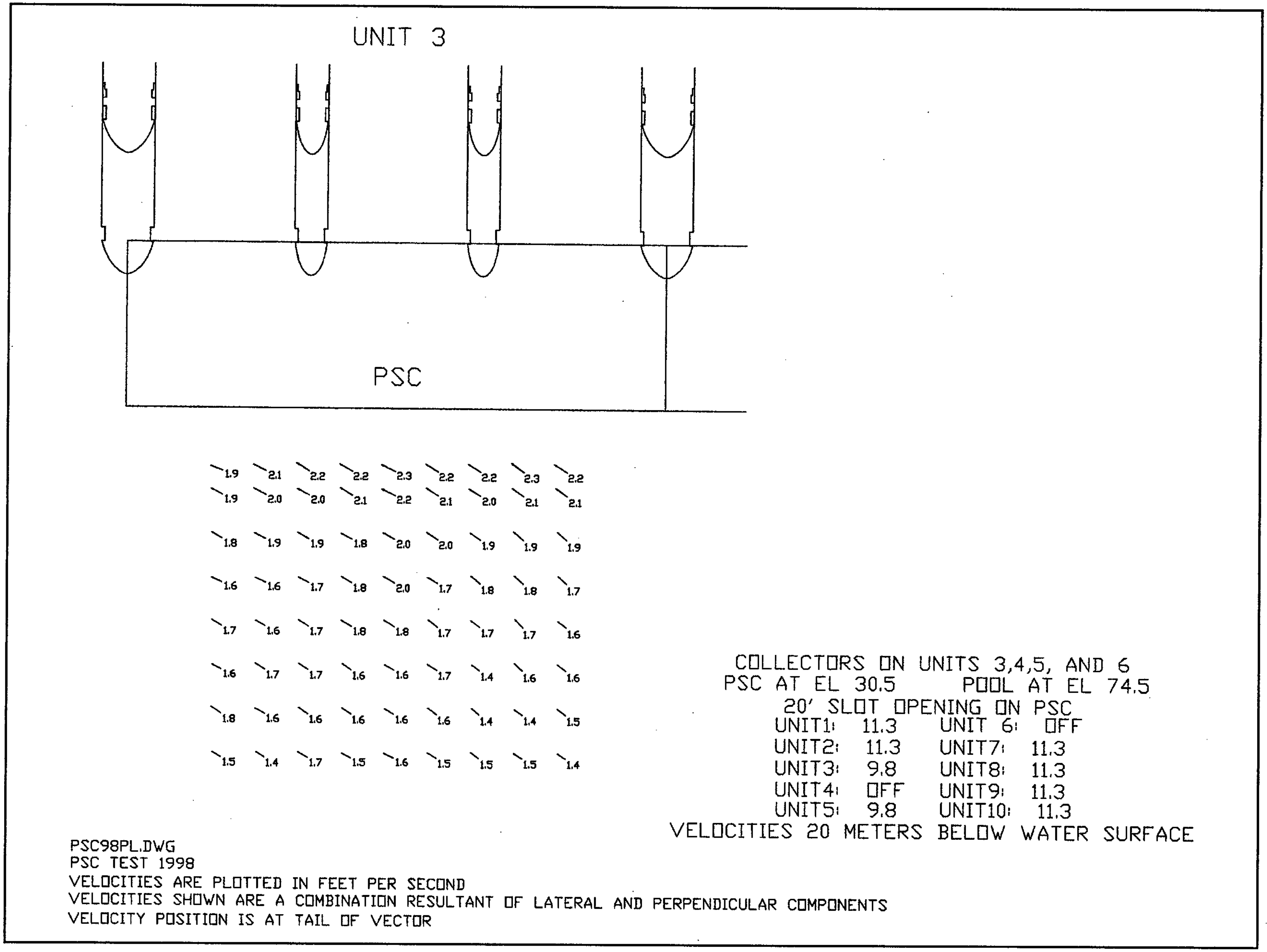
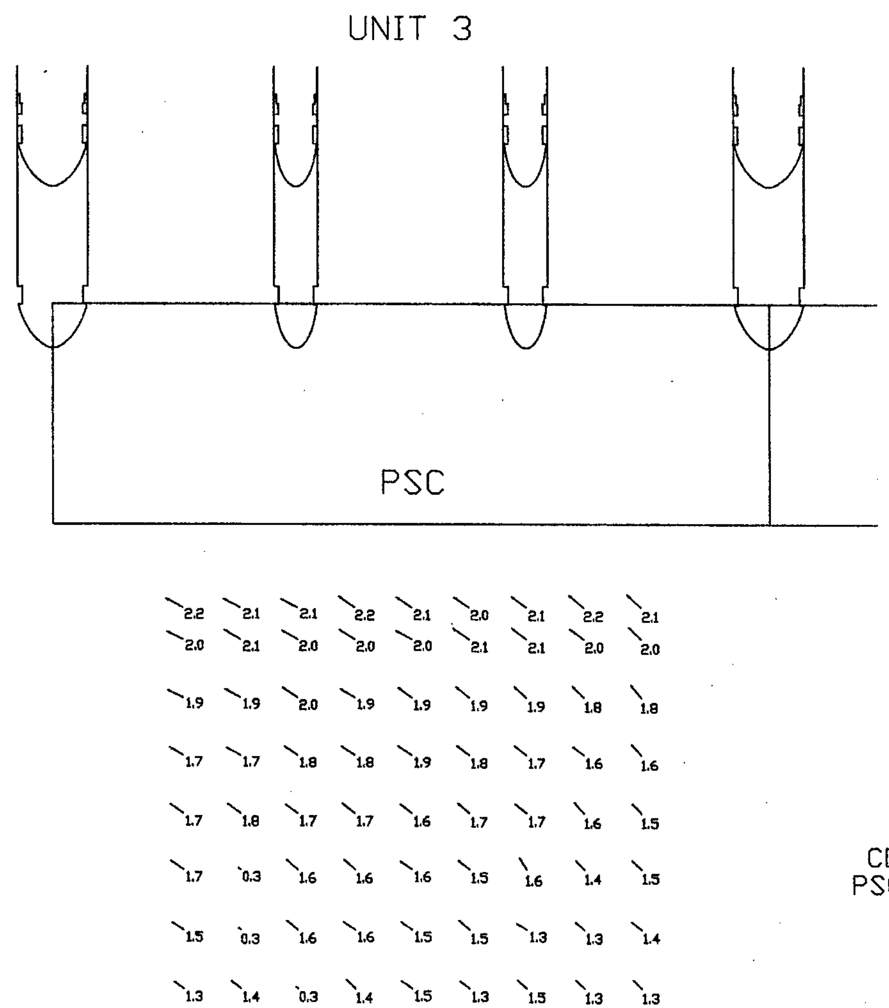

UNIT 3
PSC
1.9 2.1 2.2 2.2 2.3 2.2 2.2 2.3 2.2
1.9 2.0 2.0 2.1 2.2 2.1 2.0 2.1 2.1
1.8 1.9 1.9 1.8 2.0 2.0 1.9 1.9 1.9
1.6 1.6 1.7 1.8 2.0 1.7 1.8 1.8 1.7
1.7 1.6 1.7 1.8 1.8 1.7 1.7 1.7 1.6
1.6 1.7 1.7 1.6 1.6 1.7 1.4 1.6 1.6
1.8 1.6 1.6 1.6 1.6 1.6 1.4 1.4 1.5
1.5 1.4 1.7 1.5 1.6 1.5 1.5 1.5 1.4
COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC
UNIT1: 11.3 UNIT 6: OFF
UNIT2: 11.3 UNIT7: 11.3
UNIT3: 9.8 UNIT8: 11.3
UNIT4: OFF UNIT9: 11.3
UNIT5: 9.8 UNIT10: 11.3
VELOCITIES 20 METERS BELOW WATER SURFACE
PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

Plate 42

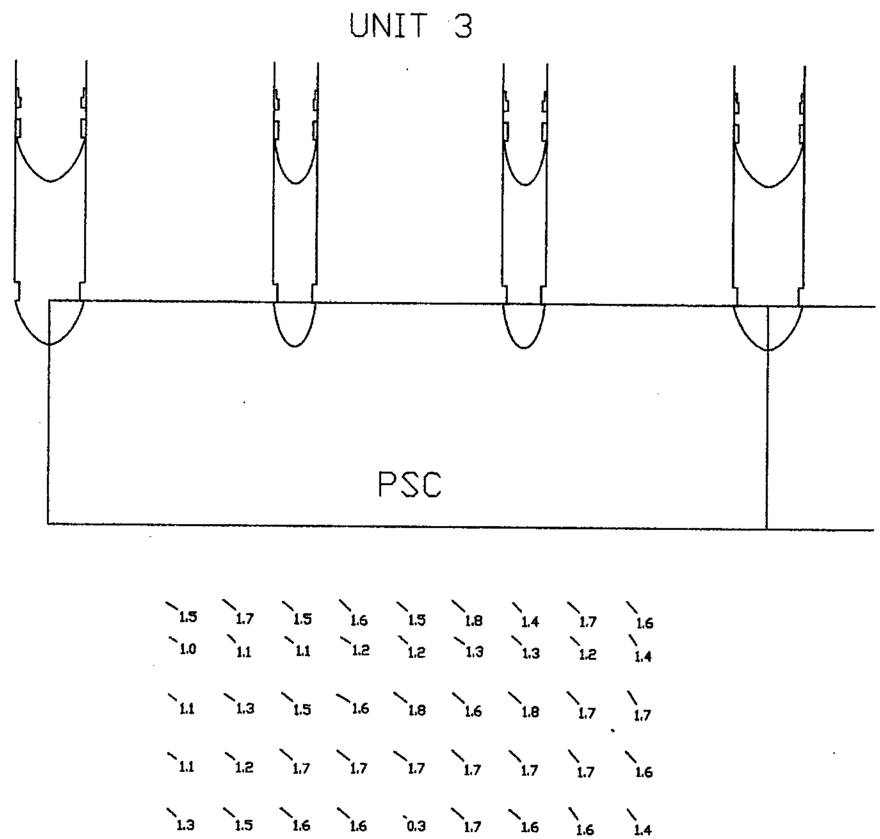


COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5 POOL AT EL 74.5
20' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 22 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR



COLLECTORS ON UNITS 3,4,5, AND 6
PSC AT EL 30.5   POOL AT EL 74.5
20' SLOT OPENING ON PSC

UNIT1:	11.3	UNIT 6:	OFF
UNIT2:	11.3	UNIT7:	11.3
UNIT3:	9.8	UNIT8:	11.3
UNIT4:	OFF	UNIT9:	11.3
UNIT5:	9.8	UNIT10:	11.3

VELOCITIES 23 METERS BELOW WATER SURFACE

PSC98PL.DWG
PSC TEST 1998
VELOCITIES ARE PLOTTED IN FEET PER SECOND
VELOCITIES SHOWN ARE A COMBINATION RESULTANT OF LATERAL AND PERPENDICULAR COMPONENTS
VELOCITY POSITION IS AT TAIL OF VECTOR

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14. ABSTRACT
Surface collectors are being studies as a possible solution for bypassing juvenile salmon around the turbines. Juvenile fish tracking studies were conducted in 1998 in the forebay of the powerhouse in the vicinity of the surface collector. A 1:40-scale model of the powerhouse was utilized to obtain three-dimensional velocity information in the same vicinity of the surface collector. The velocity information was provided to Portland District to overlay with the fish tracking data to determine if the juvenile salmon were following the flow lines into the surface collector.

15. SUBJECT TERMS
Fish Bypass Structure, Powerhouse, Surface collectors

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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